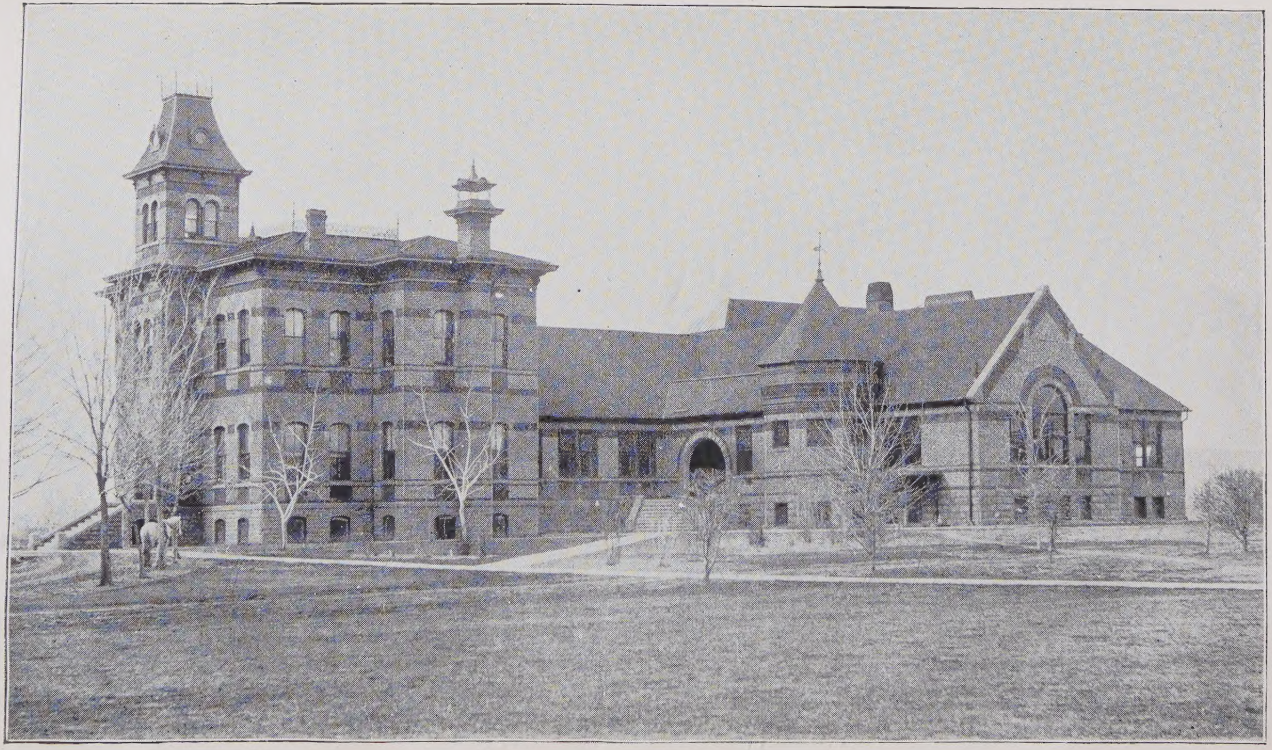

MAIN BUILDING.

Twentieth Annual Report

OF

The State Board of Agriculture

AND

The State Agricultural College

INCLUDING

The Eleventh Annual Report

OF

The Agricultural Experiment Station

Fort Collins, Colorado

1898

DENVER, COLORADO
THE SMITH-BROOKS PRINTING CO., STATE PRINTERS
1899

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FRANK H. THOMPSON, B. S.

Letter of Transmittal.

HON. ALVA ADAMS,

Governor of Colorado.

Sir—Agreeably to statutory provision, we herewith present the Twentieth Annual Report of The State Board of Agriculture under whose direction the various forms of educational and experimental work in progress at The State Agricultural College are planned and conducted. The financial condition of the College, as represented by the annual receipts and expenditures, is set forth in the statements contained in the report of the Secretary of the Board; some of its educational features, including certain principles of administration that are held to be fundamental, are clearly presented in the comprehensive report of the President of the Faculty. The College, in all its departments, is in a prosperous condition. Its educational work is made to touch closely and practically some of the most important of the material interests of the State. That work is, also, of high intellectual and moral value, made so by the system of instruction and discipline now operative.

Respectfully submitted,

A. L. KELLOGG,

President of The State Board of Agriculture.

J. E. DuBOIS,

Secretary of the Board and Faculty.

ALSTON ELLIS,

President of the College.

Secretary's
Statement of Receipts and Expenditures

Connected with the "General Fund," for the Fiscal Year Begun December 1, 1897, and Closed November 30, 1898.

GENERAL FUND.

Receipts:

Land Income Fund (Congressional Act of 1862 for the Endowment of an Agricultural College in Colorado)	$ 8,849.83*	
Tax Fund (State one-fifth mill levy)	40,907.63	
Annie Jones Library Fund	31.00	
Special Fund	146.09	
Total Receipts		$49,934.55

Disbursements:

Salaries	$10,824.72
Secretary's Office	98.33
Library	325.15
Military Department	60.30
Horticultural Department	1,653.04
Farm Department	3,708.47
Chemical Department	263.48
Mechanical Engineering Department	2,088.97
Department of Zoölogy and Entomology	152.40
Department of Domestic Science	84.78
Commercial Department	967.98

*The amount of this fund varies from year to year. The average yearly income from this source, based upon the receipts for five years is $5,526.66.

Department of English and Philosophy	16.70	
Department of Irrigation Engineering	222.74	
President's Office	267.46	
Advertising	774.55	
Printing Catalogue	325.00	
Farmers' Institutes	104.35	
Text-book Account	2,255.59	
Student Labor	1,029.41	
Furniture	318.72	
Current Expenses	1,718.81	
General Repairs	671.44	
Freight (coal) and Express	1,964.93	
Fuel and Light	1,641.87	
State Board of Agriculture	1,155.90	
Insurance	1,259.50	
Chemical Laboratory	15,979.96	
Total Disbursements		$49,934.55

UNITED STATES OR "MORRILL FUND OF 1890."

For the Government Fiscal Year begun July 1, 1897 and ended June 30, 1898.

Receipts:

Balance, July 1, 1897	$ 83.29	
United States Draft	23,000.00	
Total Receipts		$23,083.29

Disbursements:

Salaries	$18,740.32	
Department of Mechanical Engineering	1,433.31	
Chemical Department	2,191.74	
Department of Irrigation Engineering	707.92	
Balance, July 1, 1898	10.00	
Total Disbursements		$23,083.29

President's Report.

June 1, 1898.

TO THE STATE BOARD OF AGRICULTURE:

Gentlemen—The college-year, one term of which had passed prior to the annual meeting of the Board in December last, will close with the exercises of Commencement Day, Thursday, June 2d. The scholastic year includes thirty-nine weeks divided into three terms of equal length. Under our scheme of instruction, the division of the college-year proves very satisfactory. It enables the Faculty committee on student classification to perform its work more thoroughly, thereby increasing the opportunities for effective class-room and laboratory work.

The annual catalogue of the College was received from the printers before the first of May. Since that date about two thousand copies—one-half of the total number printed—have been judiciously distributed. This publication is of creditable appearance and contains information upon all phases of educational work for which the College makes provision.

The number of students reported at the close of the Fall term has been increased by twenty-eight.

In this connection is presented the summaries of student enrollment and classification for the two years just closed.

SUMMARY FOR 1896-'7.

	Male.	*Female.*	*Total.*
Post-Graduates	6	1	7
Seniors	7	5	12
Juniors	21	6	27
Sophomores	34	10	44
Freshmen	33	33	66
Sub-Freshmen	41	22	63
Preparatory Class	17	6	23
Commercial Course	61	20	81
Irregulars	3	9	12
Total	223	112	335

The students represented fourteen states and one territory, as follows: California, 4; Colorado, 307; Illinois, 2; Indiana, 1; Iowa, 1; Kansas, 2; Missouri, 3; New Mexico, 2; New York, 2; North Carolina, 1; Ohio, 1; South Dakota, 1; Washington, 1; Wisconsin, 2; and Wyoming, 5. Total, 335.

The Colorado students represented twenty-seven counties, as follows: Arapahoe, 14; Boulder, 13; Clear Creek, 3; Chaffee, 11; Conejos, 3; Delta, 8; Dolores, 1; Douglas, 1; Eagle, 6; Elbert, 2; El Paso, 2; Fremont, 10; Garfield, 2; Grand, 3; Gunnison, 3; Huerfano, 3; Larimer, 188; Las Animas, 3; Logan, 1; Mesa, 1; Montrose, 1; Otero, 4; Ouray, 1; Park, 2; Routt, 2; Saguache, 1; and Weld, 18. Total, 307.

SUMMARY FOR 1897-'8.

	Male.	*Female.*	*Total.*
Post-Graduates	6	1	7
Seniors	12	1	13
Juniors	24	1	25
Sophomores	33	15	48
Freshmen	45	16	61
Sub-Freshmen	38	19	57
Preparatory Class	28	17	45
Commercial Course—Seniors	6	3	9
Commercial Course—Juniors	51	19	70
Special Class Students	2	7	9
Total	245	99	344

Agricultural Building.

The students represented twelve states and two territories, as follows: Colorado, 314; Illinois, 1; Iowa, 2; Kansas, 3; Kentucky, 1; Michigan, 1; Missouri, 3; Nebraska, 1; Ohio, 2; South Dakota, 1; Tennessee, 1; Wyoming, 8; Arizona, 1; and New Mexico, 5. Total, 344.

The Colorado students represented thirty-three counties, as follows: Arapahoe, 12; Boulder, 17; Clear Creek, 6; Chaffee, 5; Conejos, 2; Delta, 9; Dolores, 1; Douglas, 1; Eagle, 7; El Paso, 8; Fremont, 3; Garfield, 1; Gilpin, 1; Grand, 4; Gunnison, 3; Huerfano, 3; Jefferson, 1; La Plata, 1; Larimer, 190; Las Animas, 1; Mesa, 2; Morgan, 1; Otero, 1; Park, 1; Phillips, 3; Pitkin, 2; Pueblo, 1; Rio Blanco, 2; Rio Grande, 3; Routt, 2; Summit, 1; Weld, 18; and Yuma, 1. Total, 314. Since the publication of the last catalogue, three students, two males and one female, have been registered.

The fact that so large a number of our students come from Larimer, Weld, and Boulder counties has evoked some unfavorable comment in certain quarters. If this is a matter for criticism, there is not an educational institution in Colorado—state or church—that can claim exemption from censure. All educational institutions, and particularly those in a sparsely-settled country, draw largely upon the population in their immediately vicinity for patronage. That condition of affairs existed at the university from which I graduated thirty-one years ago; and it exists in as marked degree to-day. It does not seem just that the College should bear wholly the brunt of a criticism which, if at all deserved, is forceful against every educational institution in the State. The truth is, the criticism is not just whether it be applied to the College or any other institution of learning. It is but natural for sensible people to avail themselves of the superior educational advantages found at their doors. It would evidence disloyalty to home enterprise and a lack of business sense for them to do otherwise. People are beginning to seek homes in Fort Collins and vicinity, to the end that the superior educational advantages offered by the College

in its five distinct courses of study may be enjoyed by their children. Again, the College is located in one of the most prosperous agricultural sections of Colorado, and the well-to-do farmers who have homes therein have the means to give their children higher educational advantages than their district schools afford and have enough intelligence and foresight to avail themselves of educational facilities both wide-reaching and inexpensive. It ought not to be forgotten that the College now enrolls more students from counties of the State outside of Larimer than the total number of students registered a few years ago; also, that our present enrollment of students from other states is more than forty per cent. of the whole number of students registered in 1890. Our students now represent three-fifths of all the counties in the State. Every year brings the College to the favorable attention of a larger number of people interested in the kind of work for which it provides. That the College is liberally supported by people living in its vicinity, is strong evidence that it is worthy of the rapidly increasing patronage from abroad that it is now receiving.

In the catalogue for the present college-year appear the revised courses of study approved by the Board at the last annual meeting. A comparison of present requirements for graduation with those of the past will show a substantial uplift in the standard of scholarship. The new scheme of instruction recognizes the necessity for preparatory work and makes adequate provision for it. Entrance to the lowest class, in either of the regular courses of study, requires a higher degree of scholastic preparation than formerly. The State law, governing the admission of students to the College, reads as follows:—

"No student shall be admitted to the institution who is not fifteen years of age and who does not pass a satisfactory examination in arithmetic, geography, grammar, reading, spelling, and penmanship."

The statute states the minimum age and fixes an indefinite standard of scholarship in certain studies clearly recognized as rudimentary and forming a part of the course of study pursued in every common school in the land. Another section of the law refers to the College as "a high seminary of learning" to which the graduates of the common schools, of both sexes, shall be admitted. It would be possible for our Faculty committee to make the entrance examination in the common-school branches, named in the law, so severe that few could successfully undergo the ordeal. Thus the standard of scholarship on the part of admitted students could be raised. Possibly, the law having with some degree of definiteness fixed a *minimum* of attainment to be possessed by the applicant for admission to the College, it is left to Faculty discretion to establish any standard of a *higher* character. If this interpretation of the law will hold, it is clearly desirable to cut off at the lower end of the course and to make additions to the upper. In the not distant future, I hope to see a regular course in the College represent an amount of work and training fully equal to the best that lies between the completed course of a good high-school and that of one of our best universities—it being understood that the work of the College is always to be a clear-cut differentiation from that of either of the educational agencies named.

So long as the high-school courses are made to prepare those who pass through them for admission to the classical college and the university, there can not be a very close articulation of their work with that of institutions whose prominent features are of scientific and technical trend.

The public-school pupil who comes to the College with the preparation acquired by the proper completion of the work of the eighth-year grade can reasonably expect, by faithful effort, to complete any one of the four regular courses in five years or the commercial course in three. I favor the gradual elevation of the present

standard until a diploma will represent still another year's training.

The College is preëminently a scientific and technical institution and there is no thought, in any quarter, of making it anything else. It has ever been my strong desire to see our scientific and technical work made just as thorough, practical, and far-reaching as possible. Facilities for the more successful prosecution of this work have been greatly increased within the last few years. The appropriations for the equipment of the scientific and technical departments of the College have been generous. In fact, they have practically taken all the money available for adding to departmental equipments. The best and most expensive buildings on the college grounds are those in which class-room and laboratory work in irrigation, agriculture, horticulture, chemistry, and mechanics is carried on. Within the last six years, a sum not much below $70,000 has been expended in buildings for these departments of college work. Four rooms of the Main College Building are given up for instruction and work in zoölogy and entomology. The work in domestic science is carried on in a building which, while not of great cost, is well-planned and serviceable in all its parts. The equipment of this building represents an expenditure of nearly $1,000.

"To promote the liberal and practical education of the industrial classes in the several pursuits and professions of life," it was thought advisable, two years ago, to make more adequate provision for instruction in those branches that prepare for a "business life,"—commercial arithmetic, penmanship, bookkeeping, business correspondence, commercial law, stenography, typewriting, etc.,—and since that time more than $1,500 has been spent in securing the necessary equipment for prosecuting the work.

A largely increased attendance of students has made necessary the employment of additional instructors, by far the larger number of whom are now connected with the scientific and technical departments of the College.

In the face of facts like these it would be amusing, were it not so annoying, to hear fears expressed that the College, in its instruction and work, is being rapidly pushed away from its only safe anchorage and forced into active and unprofitable competition with the literary and classical institutions of which, it is thought, there is already an overplus. If there is any failure in our scientific and technical work I, both as President of the College and member of the Board, do not hold myself in any wise responsible therefor; for at all times I have been a consistent and persistent advocate of every plan and expenditure that gave any promise of making our scientific and technical work more efficient and far-reaching. As Chairman of the Purchasing Committee, I have gone to the limit of the college revenue in authorizing the purchase of equipments and supplies for the scientific departments of the College; and, to-day, as a result of a liberal policy towards them, they are well furnished for the special work for the promotion of which they were established.

In my last report, as Director of the Experiment Station, I showed clearly that our scientific workers were giving a constantly increasing portion of their time to special investigations connected with scheduled station work. This brings a necessity for putting more and more of class instruction under direction of assistants, whose number has been much increased of late years.

Increase the number of students and classes must be increased in proportion; then, necessarily, comes the need for an increase in the teaching force. The unmistakable tendency is for the head of a scientific department to devote himself more and more to special scientific research and more and more to place the work of class instruction and the student laboratory practice under the control of his assistants. From different parts of the State come demands upon the time and knowledge of the scientific expert. These, if met, force a certain neglect even of the *supervision* of the work of instruction going on in the classes of the department. The stu-

dents suffer loss in knowledge and training, that some scientific work of questionable utility may be prosecuted by the professor under whom they are placed for instruction. It is not a wise thought, or one in accord with the plain, unmistakable intent of the various acts —Congressional and Legislative—under which the College is operated, that our scientific workers should be relieved from teaching work and be permitted to give their whole time to such scientific investigations as would show desirable results in the better and swifter advancement of the agricultural interests of certain localities within the State. The ultimate interests of the State, even along lines regarded as intensely practical and beneficial in advancing our material prosperity, will be best promoted by our scientific specialists if their class-room and laboratory instruction is fruitful in sending forth from college halls an earnest body of intelligent workers well-equipped, by reason of their special scientific training, for the successful prosecution of just that practical work which, it is now thought, none but the college specialist in science can profitably undertake.

I look with disfavor and misgiving upon the pronounced tendency to relegate college instruction to inexperienced assistants, even though they be scholarly and ambitious. The student who is induced to go to college by catalogue statements of wisely-planned courses of study, great facilities for scientific work in the way of laboratory equipment, and the naming of distinguished specialists that form the teaching body, have some right to expect, when they enter upon their collegiate work, the best service the college, through its teaching agencies, can furnish. To place them in charge of timidity and inexperience is to do them a grievous wrong and to deprive them of just that experienced and scholarly oversight in class-room and laboratory the expectation of which was their chief inducement to enter upon a course in college. Edward Everett Hale, whose language I quote from "School Economy," voices my sentiments upon the question now under treatment. He

says: "It is an open secret, perhaps, among the presidents and trustees of colleges that it is very hard to make the best teachers take up 'freshman work.' Yet freshman work is the most difficult and the most important. What follows is that the freshman, perhaps eager to take up the full advantage of college life, passes from the high-school or the academy to his first recitation or lecture, to find himself given over to the oversight of some young fellow only four or five years older than himself, who has recently been named as tutor or instructor. The pupil has perhaps just left the personal class of a first-rate educator,—a man of experience, enthusiasm, and genius,—and he finds himself under the tuition of a frightened young graduate, afraid of his class, new to the subject, who is trying his experiments in education."

The matter of discipline, not wholly in the mental field but in the just understanding and observance of wholesome college regulations, is of prime importance as a part of the legitimate end of college training. The mind untaught to look on the right side of things, the will under no judicious control but left to the sway of passion and unworthy impulses, give indications of nothing worthy in life. Our students are, many of them, young and stand much in need of wise instruction by *experienced* teachers, upon many subjects which no course of study can definitely outline. Wholesome college discipline is assured only when there is a proper *esprit de corps* animating the larger part of the student body. Here is where the real professional power of every head of a college department, as a teacher, can make itself discreetly felt. A weakling in charge of a class can do much to demoralize its membership. This is but an instance where prevention of disease is better than the application of many remedial agents after it has become deep-seated and, perhaps, chronic. Heretofore, I have had occasion to commend in strong terms the general orderly conduct of our students. Efforts at securing right conduct on their part were not strained nor was there oc-

casion for the display of much governing power to secure their uninterrupted attention to their work. This general good order was in marked contrast with the senseless, disorderly, lawless conduct which marred the college life of some students in other institutions. Our students have access to the publications of sister institutions in which are often chronicled in glowing, enthusiastic terms the foolish pranks of students. Some newspapers give special prominence, in their columns, to glowing descriptions of every student escapade that smacks of idiocy, insubordination, and rebellion. The surest way of patting insubordination on the back and giving a semblance of heroism to its promoters, is to print a picture of the ringleader of rebellion and publish in connection therewith a glowing tribute to the manly, independent qualities that brought him into "irrepressible conflict" with the college authorities.

It is a marked characteristic of our people that they are restless under any restraint however judicious and wholesome. They are so tenacious of what they conceive to be their own rights and privileges that they sometimes become blind to what is due from them to other people. It is imperative that college authorities give the matter of college discipline well-considered attention. Ignorance and vice have already strongly recruited the ranks of the idlers and law-breakers. The feeling has been that the education of our youth in school and college was a sure means of weakening the ranks of those disorganized forces that threaten the well-being of society and the perpetuity of good government. Recent multiplying manifestations of what is inaptly called "college spirit" and "class spirit," in some of the leading educational institutions of the country, suggest the speedy and judicious exertion of faculty energy in the way of compressing student activities within the limits of order, decency, and law. "Without above himself he can erect himself, how poor a thing is man," is the thought of an ancient writer. To distinguish between freedom and license, to claim for ourselves only that which we are willing to

grant to others, and to place the general good above the realization of merely selfish ends mark the just man and the good citizen. A mind whetted to keenness by a college training can make a perverted conscience a deadly weapon with which deeply to wound society and the state. Respect for law and obedience to its commands are not so common as they should be. One generally lays claim to great forbearance if he yields even tardy obedience to a law which operates, if enforced, to interfere with the accomplishment of some of his selfish aims.

The discipline of the college should not be needlessly strict nor enforced with undue severity. A college regulation that does not look to the promotion of the general good through the individual welfare of the students is unworthy of a place on the faculty record. Rules few in number, wisely ordered in view of exigencies arising in college life, and, while impartial in their *general* application, enforced with a discrimination necessary for *special* cases, suggest a use of college authority efficient, promotive of right relations between faculty and students, and rightly educating in its operation.

The system of text-book supply is proving satisfactory. The general plan is to secure the necessary text-books for students at wholesale rates. There is no loss to the college treasury by reason of these book purchases. When purchases and sales are compared, at the close of any given year, it will be found that the college treasury is the gainer by a small amount. Since the last report, books and supplies representing $935.32 have been sold. The books and supplies on hand are inventoried at $1,-846.33.

In view of the appropriations required for the completion of the Chemical Laboratory, there has not been the usual sum expended in the purchase of equipments and supplies for the various departments. The Purchasing Committee has used its best judgment in curtailing expenses. It is believed that no department of college work has been seriously hampered by this enforced economy. The value of additional equipment is recognized

but it is not possible to secure it at this time with the means at our disposal. The new building is completed and some of its necessary equipment is provided for. There are expenses ahead that can not be avoided. They can be met only by the most rigid economy in the use of the college revenue. It is well-nigh impossible to impress this fact upon the minds of some having to do with college expenditures. Thus the duty of the Purchasing Committee is made unnecessarily irksome. A responsibility rests upon the members of that committee that will be met with as little friction as possible.

A new boiler in the Mechanical Engineering building is a necessity. The greatest care has been necessary to make the old boiler serve the required purpose to the close of the present year. Its longer use is out of the question. It stands condemned by the State Boiler Inspector and must go. A new boiler, with proper housing, will not cost less than $2.500. It is possible by giving the boiler a temporary setting to lessen the cost nealy a half, but that course will prove expensive in the end.

The removal of the Department of Chemistry to the new building leaves the one formerly used by it vacant. Under better financial conditions, it would be good policy to tear down the old building and thus remove from the college campus what all regard as something of an eye-sore; but the need of room is so pressing and the means of furnishing it so meager, that the destruction of the old building can not be recommended at this time. There is service in that old, time-worn structure yet, and necessity forces us to secure it. Careful computation of cost has not been made, but it is believed that the proper expenditure of $500 will put the building in condition for accommodating the varied work now in progress in the Commercial Department.

Few additions have been made to the College Library within the year. The money for the purchase of new books was not available. The list of periodicals was revised and reduced, a measure forced by lack of funds.

One piece of property belonging to the "Annie Jones Library Bequest" remains to be sold. The proceeds of such sale, when made, will become immediately available for the purchase of new books. The sale of the property is not forced because there is no demand for it at present and because there is no room for the proper care of the books which the money realized from such sale would secure. The need of more enlarged quarters for the Library is apparent to every one who visits the rooms where the books are now shelved.

Another need which, though pressing, can not be supplied, and for that reason is merely mentioned, is a building that will furnish at least four additional classrooms. Present conditions bring a time-wasting change of instructors from building to building at each signal that marks the close of a recitation period.

In connection with this report, is presented the usual statements of the heads of departments; also a petition from certain Faculty members praying for an increase in their salaries—all of which is presented without recommendation as each will, no doubt, have its reference to the proper Board committee for report.

In conclusion, it is a pleasure to report my conviction that the College is becoming more widely and more favorably known each year. The people of our State are having a juster conception of the work which it is the special province of the land-grant college to promote and, as a consequence of this more enlightened and rational view, criticism when offered is more just and complaint when heard less bitter. With few and unimportant exceptions, the papers of the State have for the College and its work nothing but words of encouragement and commendation. Public sentiment at the open doors of the College is strongly concurrent in its favor. The College merits and is receiving the warmest support of the outside world most nearly in touch with it and most conversant with what is in progress within its walls. This loyal support from those near by is very gratifying to all engaged in college work. I need not refer to the pleas-

ant relations that exist between the members of the Board before which this report is read. At no time since my connection with the College, have those relations been so considerate, so unselfish, and so courteous as now. To say that to work under such direction is to render service under pleasant, helpful, and encouraging conditions is but to repeat what I have had occasion many times to say to others within the last year.

Respectfully submitted,

Alston Ellis,

President.

President's Report.

December 14, 1898.

TO THE STATE BOARD OF AGRICULTURE:

Gentlemen—Six months ago, at the semi-annual meeting of your Honorable Body, I presented a brief report making some statements and setting forth some facts relating to the work of the college-year then closing. Should the publication of a report embodying financial statements, enrollment statistics, and the like be authorized at this time, I would suggest that the written report presented by me for your consideration last June form a part thereof.

The two years that have passed since the last publication of a report have brought continued prosperity to the Institution. At no time in its history has it been so well-equipped for the prosecution of its various forms of educational work as it is now. It is not too much to say that, in the educational field, it is doing a work of the highest importance to the State—a work which no other institution of learning, within our borders, can do or ought to do. It is the definite aim of the authorities of the College—an aim never lost to view—to differentiate its work from that of every other educational institution in the clearest manner possible. There is a general area of educational work that all institutions of learning may properly cultivate. All the courses of study, now in successful operation in the College, make pretty full provision for the *general education* of the students who enter upon them. After a desirable general culture is acquired by the student, the next aim is to

bring him in theoretical and practical contact with "such branches of learning as are related to agriculture and the mechanic arts." In the latter work, the scientific and technical departments of the College, well-manned and well-equipped as they are, show their wide-reaching influence. It is the pride of those connected with the College that all its scientific and technical work is so well ordered and successfully prosecuted. The College, by reason of its persistent efforts to strengthen its work along practical lines, is becoming one of the best scientific and technical schools in the country. Its work in most departments of science, in civil, irrigation, and mechanical engineering, in domestic economy—all that vitally touches the home life of the people—and in all the subjects taught in the comprehensive course of the business college, is of high grade and of that character best to fit students for a life of practical, remunerative service after their college days have closed. No attempt is made to force those who leave the College, either before or after graduation, to become *farmers;* but the opportunities for such instruction as will the better fit students for intelligent and profitable work on a farm are never lacking. If a student who elects to follow any of the prescribed courses, mapped out by college authority, passes over it without gaining inclination and power to do something useful and of a living-making nature, he is the exception to the well-nigh universal rule.

ENROLLMENT STATISTICS.

But little is to be reported under this caption. Only one term—thirteen weeks—of active college work has passed since the presentation of the last report. There is an increase in student enrollment, though not a marked one. The close of the Fall term, December 2, 1898, found the names of 324 students registered.

These students represent two foreign countries, thirteen states, and one territory, as follows: Mexico, 1; Turkey, 1; Arkansas, 1; Colorado, 283; Illinois, 2;

Iowa, 2; Kansas, 2; Massachusetts, 2; Minnesota, 1; Missouri, 1; Nebraska, 5; New York, 1; New Mexico, 7; Ohio, 1; South Dakota, 1; and Wyoming, 13. Total, 324.

The students from Colorado represent thirty-eight counties, as herewith shown: Arapahoe, 14; Boulder, 13; Chaffee, 3; Clear Creek, 3; Conejos, 1; Costilla, 4; Delta, 5; Dolores, 2; Douglas, 1; Eagle, 4; El Paso, 6; Elbert, 1; Fremont, 8; Garfield, 1; Gilpin, 1; Grand, 2; Gunnison, 7; Huerfano, 4; Lake, 5; La Plata, 4; Larimer, 152; Las Animas, 1; Logan, 2; Mesa, 1; Mineral, 1; Montrose, 2; Morgan, 2; Otero, 1; Ouray, 3; Phillips, 1; Pueblo, 3; Park, 1; Rio Grande, 2; Routt, 1; Saguache, 1; Summit, 2; Weld, 16; and Yuma, 2. Total, 283.

The enrollment for the Fall term of the college-year, 1898-1899, as before shown, is classified as follows:

Preparatory Class	29	
Sub-Freshman Class	65	
Students classified as Irregulars	30	
Students in Commercial College	61	
Freshman Class	50	
Sophomore Class	36	
Junior Class	30	
Senior Class	19	
Post-Graduates	4	
Total		324

Herewith are given the figures that represent the student registration of the first term of the college-year for a number of years:—

Year.	Males	Females.	Total.
1892	127	36	163
1893	93	37	130
1894	148	57	205
1895	144	62	206
1896	202	88	290
1897	225	91	316
1898	239	85	324

The enrollment statistics of late years show that the College is drawing patronage from an area that is constantly widening. The Institution has always drawn largely upon Fort Collins and vicinity for students for reasons that are obvious upon second, if not upon first thought. The College has not existed a score of years. Its location, while highly desirable in many important respects, places it beyond easy and inexpensive reach of many portions of the State. Its name, too, has given many of our own people a wrong understanding of the extent and nature of the educational field in which its scholastic effort is put forth. All institutions of a like character, in new states especially, show a local patronage widely out of proportion to that contributed by the state at large. It is a most encouraging fact that the College is making larger and larger drafts upon all sections of Colorado for students. It is not chance that brings us students from Nebraska, Wyoming, and New Mexico. Students from abroad come to us because we offer them educational advantages, in the fields of intellectual and industrial activity, which they can not better, or so well, secure elsewhere. As the work of the College, in all its many phases, becomes better known its popularity will correspondingly increase and its attendance of students will be more representative of the people of the State. Each college-year closes with the exercises of "Commencement Day" in June. The enrollment of students and the number of graduates for each year since the opening of the College is shown in the following table:—

HORTICULTURAL BUILDING

Year.	Males.	Females.	Total.	Graduates.
1880	14	11	25	0
1881	35	22	57	0
1882	49	32	81	0
1883	50	31	81	0
1884	40	37	77	3
1885	50	46	96	6
1886	45	42	87	1
1887	63	42	105	4
1888	71	38	109	4
1889	73	34	107	2
1890	56	18	74	9
1891	77	29	106	3
1892	101	45	146	9
1893	135	44	179	7
1894	142	56	198	7
1895	164	66	230	13
1896	161	71	232	12
1897	223	112	335	11
1898	245	99	344	22**
1898*	239	85	324	...

The graduates from the College who completed one of its regular courses now number one hundred and thirteen. The first class to graduate from the Commercial Department was that of 1898. The positions in the working world held by these representatives of the College testify to what it is doing in giving the industrial classes that liberal and practical education that will best fit them for the several pursuits and professions of life.

COURSES OF STUDY.

The courses of study are four, each requiring four years in addition to two years of preparatory work, and each leading to the degree of B. S.: The agricultural

*Fall term ending December 2, 1898.

**Including nine graduates from the Commercial Department.

course, the mechanical engineering course, the civil and irrigation engineering course, and the ladies' course. Provision is made for post-graduate work. The degrees of C. E. and M. E. are conferred on those worthy of holding them, by faculty action approved by the governing board. A commercial course, covering a period of two years, is established, entrance to which, requires the same qualifications as for admission to the Freshman class; no degree is given.

NAMES OF INSTRUCTORS AND REGULAR EMPLOYES WITH THEIR ANNUAL SALARIES; ALSO A STATEMENT OF THE FUND OR FUNDS WHENCE SUCH SALARIES ARE DRAWN.

Faculty—	*College Fund.*	*Station Fund.*
ALSTON ELLIS, A. M., Ph. D., LL. D., President, and Professor of Logic and Political Economy	$ 4,500.00	$ 900.00
JAMES W. LAWRENCE, B. S., Professor of Mechanical Engineering and Drawing	1,800.00	....
LOUIS G. CARPENTER, M. S., Professor of Civil and Irrigation Engineering	1,300.00	500.00
CHARLES S. CRANDALL, M. S., Professor of Botany and Horticulture	1,300.00	500.00
CLARENCE P. GILLETTE, M. S., Professor Zoölogy and Entomology	1,300.00	500.00
WELLS W. COOKE, B. S., A. M., Professor of Agriculture	1,300.00	500.00
WILLIAM P. HEADDEN, A. M., Ph. D., Professor of Chemistry and Geology	1,300.00	500.00
THEODOSIA G. AMMONS, Professor of Domestic Science	1,200.00	....
JACOB A. CHRISTMAN, Principal Commercial Department	1,200.00	....

	College Fund.	Station Fund.
Faculty—		
EDWARD B. HOUSE, B. S., E. E.,		
Professor of Mathematics	1,200.00	....
JAMES E. DuBOIS,		
Secretary of the Faculty	1,000.00	500.00
EDWARD M. TRABER, A. B.,		
Professor of English and Philosophy	1,200.00	....
JENNIE E. McLAIN, B. S.,		
Professor of History and Literature	1,200.00	....
WILLIAM C. DAVIS, 1st LIEUT. 5th ARTILLERY, U. S. A.,		
Professor of Military Science and Tactics	....	....
Stenographer—		
FRANK H. THOMPSON, B. S	840.00	....
Librarian—		
MARGUERITE E. STRATTON, B. S	650.00	....
Principal Preparatory School—		
MARY E. GILL	650.00	....
Assistants—		
JAY. D. STANNARD, B. S.,		
Physics and Civil Engineering	1,000.00	....
ROBERT E. TRIMBLE, B. S.,		
Meteorology and Irrigation Engineering	....	900.00
L. D. CRAIN, B. M. E.,		
Mechanical Engineering and Drawing	1,000.00	....
ALLEN P. GREENACRE, B. S.,		
Forge-Room Work and Drawing	600.00	....
WILLIAM F. GARBE,		
Foundry Practice	540.00	....
FRANK L. WATROUS,		
Agriculture	....	1,000.00

	College Fund.	Station Fund.
Assistants—		
EDWARD S. G. TITUS,		
Dairy, (Student help)	150.00	....
CARL H. POTTER, B. S.,		
Botany and Horticulture	....	700.00
CHARLES F. MERGELMAN,		
Floriculture and Landscape Gardening	800.00	....
LOUIS A. TEST, B. M. E., A. C.,		
Chemistry	....	900.00
FRED ALFORD, B. S.,		
Chemistry	....	540.00
JOHN E. KITELEY, B. S.,		
Chemistry	....	540.00
ELMER D. BALL, B. S.,		
Zoölogy and Entomology	....	900.00
LATHROP M. TAYLOR, B. S.,		
Stenography and Typewriting	1,000.00	....
CHARLES GOLDING-DWYRE, Jr.,		
Bookkeeping and Penmanship	500.00	....
JOHN W. NEWMAN, B. S.,		
Mathematics	500.00	....
Sub-Station Superintendents—		
HARVEY H. GRIFFIN, B. S.,		
Arkansas Valley, Rocky Ford, Colo	....	900.00
J. E. PAYNE, M. S.,		
Rainbelt, Cheyenne Wells, Colorado	....	800.00
Engineers and Janitors—		
William Kelly	780.00	....
John H. Cameron, Sr.	540.00	....
James L. Veazey	540.00	....
A. M. Wilkin	540.00	....
Isaac N. Chatfield	540.00	....

Laborers Regularly Employed—	*College Fund.*	*Station Fund.*
J. H. Cameron, Jr.	540.00	....
Alvin Fry	540.00	....
Frank Matthews	540.00	....
N. G. Strayer	540.00	....
Robert Cameron	480.00	....
J. W. Coffman	480.00	....
Total	$34,090.00	$11,080.00
General—		
Station Labor	....	2,489.20
College Labor	500.00	....
Student Labor	900.00	....
Total	$ 1,400.00	$ 2,489.20

SUMMARY.

Salaries	$34,090.00	$11,080.00
Labor	1,400.00	2,489.20
Grand Total	$35,490.00	$13,569.20

SUMMARY OF COLLEGE INVENTORIES.

NOVEMBER 30, 1898.

LANDS AND ADJUNCTS:—

Two hundred and forty (240) acres of land at an average value of $100 per acre	$ 24,000.00	
Trunk sewer to the Poudre river	6,000.00	
Pipe-line for water supply	2,900.00	$ 32,900.00*

* This estimate includes numerous sewer laterals and water connections; a reservoir for storage of water; all other improvements of the College grounds; and ditch stock, worth $2,000.00.

BUILDINGS, INCLUDING PERMANENT FIXTURES:—

Main College Building	$ 36,000.00	
Mechanical Engineering Building	21,000.00	
Agricultural Building and Creamery	10,500.00	
Horticultural Building	15,100.00	
Civil Engineering Building	9,000.00	
Commercial College Building	6,000.00	
Chemical Laboratory	27,000.00	
Building for Department Domestic Science	4,650.00	
Greenhouses ($3,000) and Forcinghouse ($1,500)	4,500.00	
Barns, Toolhouse, and Shed on Horticultural Grounds	1,425.00	
Barn on College Farm	4,000.00	
Sheep Barn and Paddocks ($600); Implement House and Shed ($450); Pig-pens ($300); Other Stock-pens ($350); Root-cellar and Silo ($250); Fencing ($1,450) on College Farm	3,400.00	
Farm Dwelling House	2,700.00	
Depot, Hose-house, and Apiary	700.00	145,975.00
Grand Total		$178,875.00

DEPARTMENT INVENTORIES:—

History and Literature	$ 400.00	
English and Philosophy	189.17	
Mathematics	572.85	
Military Science and Tactics	7,338.05	
Zoölogy and Entomology	4,953.85	
Mechanical Engineering and Drawing	14,306.95	
Agriculture	6,072.00	
Botany and Horticulture	6,573.93	
Civil and Irrigation Engineering	10,227.63	
Chemistry	2,870.65	
Domestic Science	870.68	
Commercial Department	1,793.24	$ 56,169.00

MISCELLANEOUS—

President's Office No. 1	$ 3,878.17	
President's Office No. 2	2,254.50	
Secretary's Office	494.28	
Director's Office	865.50	
Library	10,752.28	$ 18,244.73
Grand Total for College		$253,288.73

SUMMARIES.—

Total value of College property, 1891	$144,568.98
Total value of College property, 1892	176,600.26
Total value of College property, 1893	187,847.53
Total value of College property, 1894	197,633.76
Total value of College property, 1895	207,411.83
Total value of College property, 1896	212,699.52
Total value of College property, 1897	232,667.62
Total value of College property, 1898	253,288.73

EXPERIMENT STATION INVENTORIES.

NOVEMBER 30, 1898.

AGRICULTURAL SECTION, FORT COLLINS:—

Farm Implements	$ 103.00	
Dairy Supplies	350.00	
Office Fixtures	374.00	$ 827.00

HORTICULTURAL SECTION, FORT COLLINS:—

Instruments and Supplies	634.59	634.59

SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING, FORT COLLINS:—

Meteorological Instruments	383.40	
Irrigation Apparatus	376.28	
Hydraulic Apparatus	166.95	
Stationery and Office Supplies	142.31	1,068.94

ENTOMOLOGICAL SECTION, FORT COLLINS:—

Laboratory Supplies	78.45	
Entomological Supplies	84.65	
Insecticides and Apparatus	101.00	
Apiary Supplies	162.95	
Microscopical Apparatus in Charge	335.00	762.05
Total for Home Station Property		$ 3,292.58

ARKANSAS VALLEY STATION, ROCKY FORD:—

Two hundred (200) acres of land	$ 9,800.00	
Water Rights and Apparatus	1,858.00	
Buildings and Fencing	2,372.80	
Live-Stock	166.00	
Farm Implements	553.75	
Farm Products on Hand	711.90	15,491.20

RAINBELT STATION, CHEYENNE WELLS:—

One hundred and sixty (160) acres of land	200.00	
House, Barn, Fencing, etc	1,265.00	
Farm Products and Supplies on Hand	91.05	
Live-Stock and Implements	348.85	1,904.90

SAN LUIS VALLEY STATION, MONTE VISTA:—

One hundred and sixty (160) acres of land	2,110.00	
Twenty (20) inches of water in the Rio Grande Canal	300.00	
Buildings, Fencing, and Well	1,497.00	
Horses, Wagon, and Harness	177.00	
Farm Implements, etc	54.90	4,138.90

DIVIDE STATION, MONUMENT:—

Forty (40) acres of land	200.00	
Buildings	600.00	800.00
Total Sub-Station Property		$22,335.00

SUMMARIES:—

Grand Total Experiment Station Property, 1898	$25,627.58
Grand Total Experiment Station Property, 1897	25,643.54
Grand Total Experiment Station Property, 1896	25,289.62
Grand Total Experiment Station Property, 1895	27,086.78
Grand Total Experiment Station Property, 1894	29,797.18
Grand Total Experiment Station Property, 1893	25,037.12

GROUNDS AND BUILDINGS; NEED OF A NEW BUILDING.

The college land touches the City of Fort Collins on the south. In the north-east corner of the grounds are to be found the various college buildings. Most of the 240 acres owned by the State is given up to farm operations, general and experimental. The ground immediately adjacent to the college buildings is made use of by the Horticultural Department in the prosecution of its special lines of work. The lawns about the buildings have an abundance of ornamental shrubbery, with here and there flower-beds upon which the skill of the florist has been exerted with pleasing effect. The drives through the farm are thoroughfares at all times of the year. These drives are kept clean and well-rolled and, being well shaded in summer, are much frequented by those seeking out-of-door recreation by riding or driving.

The college authorities draw a long breath of relief in announcing the completion of the new Chemical Laboratory. Two years ago a legislative appropriation for the completion of this building was asked. It was not granted, and every dollar required for putting this building at the service of the State, both in educational work and in furthering the work of the experiment station, in which our farming communities are so deeply and vitally concerned, was taken from the regular mill-tax fund for the general support of the College. The building stands, to-day, a testimonial of the business capacity of the members of The State Board of Agriculture. Departmental equipments and library additions have suffered by reason of the rigid economy in the handling

of college funds, but it were better thus, possibly, than to face the needed efforts of a new fiscal year with a debt burden to carry.

As soon as the building that had so long served the Department of Chemistry was vacated, plans were suggested for its remodeling to render it suitable for the use of the "Business College." The expenditure of less than one thousand dollars has so changed the building as to make it serviceable in accommodating all the classes of the Commercial Department. The interior now presents a sightly appearance. The removal of partitions and other adjustments of space have given four classrooms and an office. Classes in bookkeeping meet in one room; those in banking practice, in another; those in typewriting and stenography, in another; while the last room—a well arranged general classroom—gives ample quarters for classes in spelling, commercial arithmetic, commercial law, business geography, etc. The building is heated by steam, is well lighted and ventilated, and has every convenience required for the right carrying on of the work of the Department for whose use it has been put in order.

A "Mechanical Department" was created in 1882. Its work was carried on in the basement of the Main Building, immediately beneath the present library room, until the following year when a building better designed for the use of the Department was erected on the northwest corner of the campus. This building has been remodeled and enlarged until now it covers a large area. Here is to be found the machinery and other equipment made of highest utility in prosecuting the well-planned and varied work of the present Department of Mechanical Engineering.

In the summer of 1898, a new 80-horse-power boiler was put in place at a cost of $1,100. The old boiler had outlived effective service and was a menace to life and property. The new one is of approved design and good workmanship and will furnish all the power needed to run the extensive plant.

The need of a building suitable for carrying on laboratory experiments in mechanical engineering has long been felt. Through the generosity of some public-spirited citizens of Fort Collins that need will exist no longer. Voluntary contributions have been made to a fund that is now large enough to insure the speedy completion of a building for special experimental and practical work in advanced mechanics. The purpose of the building and its general appearance, are set forth in an article recently published in "THE ROCKY MOUNTAIN COLLEGIAN," a paper devoted to student interests, from which quotation is made:

"The laboratory idea is one of the strong features of the College. The Mechanical Engineering Department has gradually been brought to a high degree of usefulness, and those who have watched the growth of this branch of the college work have become much interested in it, and it has become a feature which is very attractive to those who visit the Institution. The students who have taken up this line of work have, for the past two or three years, been given considerable advanced work, and original investigations and experiments have been undertaken with the limited accommodations at hand; so valuable to the students has this work proved, and so earnestly have they desired it, that much encouragement was felt still further to furnish the necessary accommodations to do work similar to that of the older and larger institutions of the country."

"The object of the work of the laboratory is to give the advanced students an opportunity to make investigations of the physical properties of materials of construction entering into buildings, machinery, and other structures; and also to make tests and examinations of different kinds of boilers, engines, motors, pumps, and all kinds of mechanical appliances which may be obtained for the use of the department. This opens up a splendid and valuable field to the students of the College, not before available, and the experiences obtained here will be of inestimable value to them. Other institutions of this kind throughout the country are rapidly providing conveniences for this work, and our own institution is to be congratulated for keeping in the van."

"The work does not interfere in the least with that of any other department, and is an added help for the department for which it is designed. Nor does it disarrange the plans of the

Mechanical Department, but enables the work to be extended in a most satisfactory manner. A number of pieces of apparatus had already been given, by generous parties, for carrying on this work before the possibility of a building was known."

"The building will be situated directly south of the present Mechanical Engineering Building and will be known as the Mechanical Engineering Laboratory. It will be 40 feet wide and 60 feet long, and built of brick."

The total value of all state property now under the control of THE STATE BOARD OF AGRICULTURE is nearly $279,000. All this property has been secured from drafts upon the mill-tax fund voted for general college maintenance, save $49,500 voted by the Legislature for the erection of college buildings and for sewer construction, and $2,500 appropriated by the same body for the establishment of an experiment station at Cheyenne Wells in Cheyenne county.

Two years ago, in the annual report prepared just prior to the biennial session of the General Assembly, I outlined with some care the needs that seemed most pressing in the hope that a special legislative appropriation would be made to meet them. A small appropriation—still a very helpful one—would have been secured had not a dead-lock between the branches of the

General Assembly delayed legislative action on a number of appropriation bills until the legal limit of the session had been reached.

The highest legal tribunal of the State has decided that appropriations for improving the grounds belonging to state institutions by drafts upon the Permanent Improvement Fund, and other funds of a like nature, are contrary to law. The general revenue of the State, then, must be looked to for meeting all special legislative appropriations for the use of these institutions. That revenue has been a gradually diminishing quantity of late years by reason of the falling off in the valuation of the property by the general taxation of which —under the constitutional four-mill limit—it is secured. A recognition of the limitations thus placed upon our law-making body in the matter of making appropriations, other than those provided for in former mill-tax enactments, for the state educational institutions, causes hesitation on our part in pressing for any large appropriation for building purposes however urgent the need of such appropriation may appear to us.

Something has been done within the last biennial period to make provision for meeting the needs summarized in the report issued in 1896. The statement of those needs was as follows:—

1. Completion of the new Chemical Laboratory.
2. Better quarters for the Commercial Department.
3. A new Library Building.
4. A Central Heating Plant.
5. An Electric Light Plant.
6. A Dairy-House with all necessary appliances.
7. A new building for the Department of Zoölogy and Entomology, with proper quarters for the College Museum.
8. Rooms for the College Literary Societies.

9. An Assembly Room suitable for Chapel and General Exercises.
10. An Armory, a Drill-Room, and a Gymnasium combined.

The most pressing need has been fully met by the completion and occupancy of the new Chemical Laboratory. The Commercial Department now has ample and desirable quarters in the building formerly occupied by the Department of Chemistry. Thus two of the ten needs specified two years ago have been adequately provided for. The next most evident need is an "Administration Building," as it may not inaptly be called. A new chapel, for assembly and public exercises, is a pressing want. It could find a place in the new building; as could an armory and a gymnasium, quarters for the library, rooms for the literary societies and Christian associations, offices for different persons connected with college administration, study rooms for students, reception rooms, and the like. A building as large as the new Chemical Laboratory, recently completed, would answer the needs of the College, in the matters referred to, for years to come. A state appropriation of $30,000 would suffice for the erection of the building and its equipment for use. The removal of the library and administrative offices from the Main College Building would vacate rooms that could at once be used by the Department of Zoölogy and Entomology. The present crowded condition of the Museum would at the same time be relieved.

The present method of heating and lighting the college buildings is unsatisfactory and expensive. A central heating plant and the means of electric lighting are recommended as necessary both by efficiency of service and economy of effort and money.

When the dairy interests of Colorado is considered, when it is clearly known that it is the work of our Department of Agriculture, in its wide-reaching work, to promote these interests in the most direct way that ex-

perience and experiment may suggest, the need of suitable dairy quarters and appliances stands confessed. Our present dairy plant can hardly be said to be beyond the *infancy* state. Means are not present for the successful prosecution of experimental work of much vital importance to the dairymen of the State. A building, with the requisite equipment, is of prime importance if any further effort to suggest profitable methods of conducting a dairy is to be made.

COLLEGE FINANCES.

The sources of college revenue have been frequently explained. The financial support the college receives from Colorado has been growing less of late years. The mill-tax fund—one-fifth mill on the dollar—for college support is levied upon the assessed value of the taxable property of Colorado. The assessed value has undergone some queer changes in the last seven years as the figures herewith given will show.

Year.	*Assessed Value of Property.*
1892	$236,884,449.48
1893	238,722,417.05
1894	208,905,379.15
1895	201,308,969.10
1896	206,598,561.00
1897	197,276,446.00

The last compilation of assessments, that for 1898, shows the total taxable property of the State assessed, in round numbers, at $187,000,000.00. Within the last five years the assessed valuation of property subject to taxation has fallen off more than *fifty million* dollars. This means an annual loss of state revenue, for college support, of more than $10,000. In June 1892, the total enrollment of students was 146, much less than half that reported in June 1898. Thus while student enrollment is increasing rapidly, the revenue for college main-

tenance is becoming less every year. This loss of revenue would have been a more serious matter for the College had not the income received from the Government endowment funds been somewhat augmented each year.

The first Act of Congress, under which the College now receives an annual income somewhat definite, was passed in 1862. Colorado, under the provisions of that act, received 90,000 acres of land as an endowment of THE STATE AGRICULTURAL COLLEGE. Most of the land has been sold, and the sale proceeds form a permanent endowment fund amounting (Oct. 1, 1898) to $68,612.09. This permanent fund is under the control of the State, and the college revenue therefrom is the *interest* the State pays for its use. From the land unsold, and from interest upon sums due upon lands sold but not yet paid for, the College receives a further revenue amounting to no sum that can be definitely stated.

The Congressional act of 1890, for the further endowment of colleges of agriculture and the mechanic arts, has within the last biennial period given the College $47,000.

A summary of receipts, for college support, within the last two years, is as follows:—

Land Income Fund (Act of Congress, 1862).....	$14,000	
Additional Endowment Fund (Act of Congress, 1890)........	47,000	
Mill-tax Fund (State)........	70,000	
Total for Two Years........		$131,000

The Government appropriations, under the provisions of the "Hatch Act," 1887, for the exclusive support of the Experiment Station, within the same two-year period have been $30,000. No part of this fund is available for college support.

There is pressing need of such legislative action as will place the handling of all college revenue more directly by the college authorities. At present, the State Treasurer is the custodian of all college money save that

CHEMICAL LABORATORY.

received from the Government for experiment station support. To say that the present plan is not satisfactory, is to put it in mild form. The present plan of permitting the State Treasurer to handle the revenue of the College, as its treasurer, is favored by those who have been taught to believe that a great interest saving to the State results from it. This argument has no just basis in fact. The mill-tax fund, the product of state taxation, is used up about as fast as it comes into the hands of the State Treasurer. Were any accumulation of this fund to be in possession of that official, he could not, by its investment, make an interest-bearing fund of it, because he can not know, with any certainty, when its disbursement in redemption of vouchers of indebtedness duly issued by The State Board of Agriculture, will be necessary. There is no *state* fund of the College that can, with safety, be made interest bearing. There is a fund, however, that can be made to yield an interest, and that is the fund voted by Congress, under the provisions of the "Morrill Bill," 1890, for the further endowment of the College. This annual appropriation, of $24,000 for 1898, comes in the shape of *one* draft annually, upon the Treasurer of the United States. The college drafts upon this fund are made monthly. Being of nearly equal amounts throughout the year, they can be fairly estimated in advance by the custodian of the fund upon which they are drawn. At the time of the writing of this report, the fund referred to has several thousand dollars to its credit. This credit is looked to for the means, in part, of college support up to the close of the next government fiscal year, June 30, 1899. I assert that this is the only college fund that can be made safely available for the production of interest. I assert, further, that if the College has ever received *one cent* of interest revenue from that fund I have been misinformed. The State of Colorado can have no just claim to any interest which the government appropriations for college support may earn. Fair dealing would suggest that all interest earned by such ap-

propriations should be for the sole use of the College. The way to reach an equitable solution of this whole matter is to enact a law empowering The State Board of Agriculture to select its own treasurer—with proper safeguards as to bond, bondsmen, etc.—and to make this official the custodian of *all* college funds just as soon as the same may be available for use.

The plan of having a local *treasurer* to receive and disburse the experiment station fund has ever worked without friction. Not one cent of this fund has ever been misappropriated or lost. The financial statements of this officer have never met with rejection or criticism by the authorities at Washington. There is no reason to fear that the officer who has handled the experiment station revenues so satisfactorily would prove untrustworthy were he made the custodian of other funds, subject as far as their expenditure is concerned, to the control of THE STATE BOARD OF AGRICULTURE.

Much interest naturally attaches to the first Congressional act, that of 1862, making provision for the permanent endowment in each state and territory of at least one land-grant college. Under that act Colorado receives 90,000 acres of land for the permanent endowment of THE STATE AGRICULTURAL COLLEGE. Through the courtesy of Hon. L. C. Paddock, Register of the Colorado Board of Land Commissioners, I am able to present, herewith, tabulated statements showing the location of this land, the disposition made of about one-half of it, and the approximate annual revenue received by the College from the grant.

County.	Acreage Patented to State.	Acreage sold prior to Nov. 1, 1898.	Acreage remaining Nov. 1, 1898.
Baca	635.42	....	635.42
Bent	1,903.95	386.67	1,517.28
Fremont	9,585.44	4,635.61	4,949.83
Larimer	5,601.50	....	5,601.50
Las Animas	400.00	....	400.00
Montezuma	19,121.29	....	19,121.29
Otero	42,589.61	38,239.72	4,349.89
Pueblo	6,113.83	....	6,113.83
Routt	1,996.28	....	1,996.28
Total	87,947.32	43,262.00	44,685.32

The amount of permanent funds invested for the benefit of the College is $52,663.01, which sum is invested in 6% interest-bearing State warrants.

The probable income from certificates of purchase for 1899 is as follows:—

County	Permanent.	Income.
Fremont	$ 14.00	$ 14.28
Otero	5,726.22	4,930.84
Total	$5,740.22	$4,945.12

The following income from leases.

County.	No. of Leases.	Acreage under Lease.	Annual rental.
Pueblo	1	80	$ 10.00
Montezuma	7	720	146.50
Larimer	1	2,578	64.47
Fremont	5	1,240	58.00
Total	14	4,618	$278.97

The total receipts from the land-grant endowment from January 1, 1897, to September 30, 1898—a period of twenty-one months, were as follows:—

Permanent fund	$9,554.97
Income fund	9,009.45

No portion of the permanent fund is available for college support. Any interest return from its investment is, under limitations named in the Congressional act, a source of financial support to the College.

It will be seen that of the 90,000 acres of land to which the College is entitled, there yet remain 2,052.68 acres unpatented. Steps have been taken to locate this land and to secure a patent therefor from the General Government.

In the older and more populous states of the Union, the annual revenue for college support derived from the land-grant endowment of 1862 amounts to many thousand dollars, giving the institution for whose benefit it was established a not inconsiderable part of its total income. In Colorado, the college revenue from this endowment can never reach a sum that will prove any large per cent. of the total sum required for college maintenance. There is need that the lands now unsold, and yet to be patented, be handled with the utmost care that the ultimate permanent endowment of the College may be swelled to the largest possible sum.

The State Treasurer is made the custodian of the permanent fund, the college endowment, the interest income from which is one source of college support. This permanent fund is generally invested in State warrants and is thus made to produce a 6-per cent. revenue for the College. By reference to a preceding paragraph in this report it will be seen that, according to figures given out from the State Auditor's office, the permanent endowment, on October 1, 1898, amounted to $68,612.09. From the statements received from the office of the Register of the State Board of Land Commissioners, under date of November 2, 1898, it is shown that the sum actually invested, and thus made interest-bearing for the College, was only $52,663.01. These figures show that about $16,-000, or nearly one-fourth of the whole endowment fund

is unproductive of any college revenue. The annual interest-income thus lost to the College approximates one thousand dollars.

COLLEGE AND EXPERIMENT STATION.

I think it is beyond discussion that the law of Congress contemplates a vital connection between the land-grant college and the experiment station. True, this union is not forced, some discretionary power being lodged with the law-making power of each state, but the evident intent of the law, known as the "Hatch Act," is that the experimental work in each state shall be prosecuted in close contact with the college and under the supervision of its governing board. The wisdom of this working policy has not been gravely questioned. Provision is made in the law, for a division of the experiment station fund between two colleges, if there be such in the same state. Where experiment stations had been established prior to the approval of the Act of 1887, the states wherein they existed were not forced to abandon them in order to share in the distribution of the fund provided by that enactment. A then existing university was entitled to the benefits of the act—by special legislative action—provided there were established in connection with it "a separate agricultural college or school, which shall have connected therewith an experimental farm or station."

When the "Hatch Act" became operative, Colorado was placed in a most favorable position for the utilization of the experiment station fund. There had been established, nearly ten years before, an educational institution, having no educational or governmental union with any other, known as "The State Agricultural College." There was no other educational institution within the state that had a shadow of a just claim to ask any portion of the grants of money authorized by that act. In the legislative act, making acceptance of the provisions of the Congressional act of 1887, is a section that reads as follows:—

"That the State Board of Agriculture shall have the control of the fund appropriated by the said act of Congress and shall disburse the same for the use and benefit of the Agricultural Experiment Station *Department of the State Agricultural College*, and in accordance with the terms and provisions of said act of Congress."

Legislative action, by Colorado, on another matter was not so wisely ordered and was not so fortunate in its issue. A number of sub-stations were established and the college governing board was required to provide for their support out of the station fund received from the United States treasury. In only one instance, in the history of the experiment station of Colorado, has there been a legislative appropriation for station support. This history is, doubtless, repeated in a majority of the states.

While state control of the experiment station work is widely permissible, under the terms of the "Hatch Act," that control does not legally extend to a division of the Government experiment station fund among a number of sub-stations. In most cases these sub-stations are unnecessary and bring about an unprofitable employment of station effort. The Government station fund is rightly used in the support of one station in each state, said station being a department of an agricultural college or school either with a separate organization or in connection with some educational institution under state control. Any other use of this fund is clearly unauthorized by the Congressional action creating it.

In this connection I may record my conviction that there are but few cases where college support is had at the expense of the experiment station fund. The converse is true in the majority of states of whose college and station organization I have knowledge. A not inconsiderable part of the time devoted to station work and much of the equipment employed in its prosecution are paid for by drafts on the college treasury.

There has been some discussion in educational conventions, and elsewhere, as to the closeness of the con-

nection that should exist between the college and the station. The closer and more vital that union the better for both interests, is an opinion I have entertained ever since my attention was given to the question. If the experiment station is to be a department of the college—and that to my mind is the plain intent of the law—its relation to the college should be on the same basis as the relation of any other department thereto. There must be no wheel within a wheel so adjusted as to admit of the possiblility of their attempting to turn in opposite directions. The president of the college is the logical head of the experiment station as he is, unquestionably, that of any other college department. I do not mean that his headship is to be shown by a direct personal supervision of departmental work or even that he is to be learnedly conversant with the details of that work, but that in his executive capacity he is the legitimate head of the whole college system whether of few or many departments. There is nothing inconsistent with a wise ordering of station work by the college executive even though he be no specialist in science and stand confessedly incapable of prosecuting experimental work supposed to be the forerunner of more successful farming. What occupant of the executive chair of an educational institution could undertake, personally, to conduct all phases of class-room and laboratory work with which his executive functions bring him in contact?

The ideal station director, as some attempt to describe him, should be a specialist in every known department of science—a chemist, an entomologist, an agriculturist, a botanist, and so on through the list until the nomenclature of scientific specialists is exhausted. It is not strange that a professor coming to the directorship of the station, with supposedly this amount of scientific qualification tacked to him and properly labeled, should soon come to regard himself as a "bigger man" than the chief executive of the college.

There is no executive function connected with the work of the experiment station that can not be per-

formed by one qualified properly to supervise the general workings of a college. A union of director and president in the same person gives coherency to all the work and is in the interest of economy and harmony. Next to the president, the agriculturist of the college would seem to be the one most naturally eligible to the office of director; but the appointment of the head of one college department to direct work with which other departments are closely connected has its obvious disadvantages.

Another question having connection with others herein suggested is, Shall the heads of college departments to whom teaching hours are assigned, constitute the scientific working force of the station? This is a question about which, as about most others, something sensible can be said on both sides. I believe there is strong reason for saying that the capable *teacher*, possessed of the true scientific spirit, will prove the most serviceable worker in the station; yet few rules are without their exceptions. The professorial duties of the station worker must be so ordered as to give him time to devote to experimental work. Herewith I insert some language found in my last report as director of the experiment station:—

"I think it can be affirmed that most scientific men who give instruction and make investigations at the same time, as do the station and college workers now in mind, have a decided preference for the experimental side of the field upon which they bestow thought and effort. Their reports show a decided inclination, on their part, to emphasize the importance of the scientific and experimental investigations which they have under way and an evident desire to be released as much as possible from the cares and duties of the class-room. The tendency in the direction indicated is too strong to escape notice. It much more than counteracts any loss of experimental attainment by reason of periodic application to the work of instructing classes and supervising laboratory exercises."

"There is a closer connection between the scientific work of an agricultural college and the experimental work of the station connected with it than is usually supposed to exist. The one qualified to conduct experiments in agriculture ought to be

one well fitted to give instruction to a class of students studying the subject. The scientific training that gives the chemist ability to analyze soils, waters, fertilizers, and food products makes him all the more serviceable in the class-room or laboratory in the presence of a body of students. The plan of articulating the work of the college and the station as closely as possible is sound in theory and fairly satisfactory in practice."

President H. C. White, of the Georgia State College of Agriculture and Mechanic Arts, speaks of the union of the school of agriculture and the experiment station with the college propei in the following langauge:—

"The school of agriculture should be the clinic of the college. In a manner, it should bear the same relation to the college that the hospital bears to the college of medicine. It should be primarily designed for those who have already received, or are at the same time receiving, the educative culture of the college proper, and it should not undertake to duplicate, or infringe upon, the pedagogic work of the college. * * * The illustrative work and training of the college farm and its attachments should be distinct from the research work, in its several lines, of the experiment station. It is, unquestionably, eminently advantageous and desirable that the station should be intimately associated with the College, particularly for the sake of the station, but for the sake of the college as well. For that matter, an investigator in one might very well (and preferably) be a teacher in the other, and advanced or graduate students of the college might be admitted to participation in the researches of the station; but the work in each should be distinct, and while they should coöperate and aid each other whenever possible, the distinctive purposes and functions of each should be carefully discriminated."

COLLEGE DISCIPLINE.

Discipline is a term that grates harshly on the ears of many super-sensitive American people. To them it savors of force, oppression, and the restriction of legitimate freedom. There never was a time in the history of our country when parental discipline, school discipline, and college discipline called for wiser ordering than now. Our people seem seized with a spirit of un-

rest that makes them uneasy under restraint however mild and salutary it may be. We boast of our free institutions and almost in the same breath give expression to words that show that liberty and license are not wholly divorced in our minds.

The right handling of college students is no easy matter; and the outcome of college administration, in as far as it affects the future relations of students with the governing agencies of the country, may be of the highest importance. Sowing wild oats in college, as elsewhere, usually brings but one crop. If there is one place above all others where order, sobriety, and decency should hold sway, that place is in an educational institution supported by money taken from the tax-payers' pockets. If educational institutions are not to train for usefulness, for honorable effort, for good citizenship, how strong an argument for their maintenance at general charge is removed. The education of the intellect is well, the culture of the heart is desirable; but, in many respects, the training of the *will* surpasses either in wide-reaching effect. The undisciplined mind is the one where the will runs riot and puts under foot the best suggestions of the intellect and the most generous promptings of the sensibilities. How to reach and develop what is best and noblest in student character, is the burning question of the day. Different conditions will evoke different agencies for the accomplishment of this end. The age and previous preparation of the student for college life have something to do with the kind of college administration proper to bring to bear upon him. The student who has reached man's estate is not properly subject to the closer supervision desirable in the case of the young preparatory student who stands, as to years and development, at the most critical period of character forming.

Shall the student body have a representative voice in college administration? I have never known such a body to which could be safely delegated any controlling voice in the government of the institution with

which it was connected. This statement, if accepted generally, may suggest that college students are not capable of self-government, even in part, and that conclusion is usually the correct one. I would willingly see heralded in a new, a more enlightened era in the management of college students. Gladly would I welcome a condition of affairs that would enable faculty ability to be felt more strongly in class-room and laboratory and less in devising ways and means to secure the orderly deportment of students.

The stumbling-block in the way of a better understanding between faculty and students, in the matter of college discipline, is the traditions of the past and the class spirit—better sometimes called fool spirit—that is made supreme even though it war against the best judgment and impulses of the better class of students. There is a thought that a college without a certain quantum of student deviltry is a back number. Fathers recount to sons, and uncles to nephews, the college diabolism in which they engaged in their student days, and young America is led more than to emulate their example when he enters upon his college career. The highest ideal of college life that can be held up to students by conscientious instructors fails of good effect under such conditions.

What is inaptly termed "class spirit" is a mischievous power that often reduces well-disposed students to a condition of slavery, their better sense all the time protesting against their thraldom. My class, right or wrong! is the shibboleth of every little noisy, turbulent clique of students, the reason for whose presence in college halls is beyond finding out. The influence of a few bold, active spirits in directing student thought and activity is known to all having experience in college administration.

There are too many student organizations connected with modern college life, and the tendency to multiply them is all too apparent. Herein are sown most of the seeds that later germinate into student escapades, col-

lege rowdyism, and a senseless opposition to constituted authority. It has been said that a council of war rarely results in a decision to fight a battle; a council of students, in the shape of a class meeting, is more than likely to bring on disturbances that can only be quelled by the wisest faculty action.

The land-grant institutions have been remarkably free from student outbreaks, manifestations of college spirit as they have been styled. The reason is to be found in such an ordering of college work as to keep students wholesomely employed. Then, until lately, the traditions of the old-time classical institutions had been a sealed book to students seeking an education in the land-grant colleges. The leaven of unrest, of impatience under salutary restraint, is working *upwards*, from the ranks of the idlers and dudes found in the elder institutions of learning, into the student bodies of our scientific and technical schools, as it has already worked *downwards* into higher grades of the public schools with pernicious result.

Self-activity, self-restraint, and self-direction—all are terms freighted with meaning. Good conduct in the presence of a constable or policeman is politic, to say the least, but it does not indicate one's habitual disposition to keep in the right path. The true test comes when good resolutions are sorely beset by covert or open assaults of wrong. Every influence at our command should be wisely employed in making worthy and exemplary men and women of our students. There is much of foolery connected with college life that could be easily suppressed by timely faculty or executive action. A single instance will illustrate. Junior "class-day" is the occasion of exercises that are, in the main, subversive of good discipline and pregnant with malicious mischief. Make the exercises of this day conform to propriety and decency or prohibit them altogether. Class publications are of the same ilk as the class-day exercises. The game secured by firing these explosives is not worth the powder burned. A writer in a recent issue of one of our

educational papers pertinently says: "Year after year there come to us from the colleges the annuals got out by the junior class, representing an enormous expense resulting in what seems to us very little product, and an unbounded attempt at wit resulting in what seems to us usually vulgarity, and always rankling unkindness. * * * We believe there is something wrong in a college course which brings its young men and women to believe that these grinds are permissible."

A common-sense, not a military, discipline is what is needed in our colleges. Respect for law, obedience to rightful authority, is not the characteristic of a slave, as some college students seem to believe, but indicative of elements of character worthy of a true freeman, for "he is a freeman whom the truth makes free and all are slaves besides." Home and school training count for much in the right or wrong preparation for college environment. Hereditary traits, also, can not be eliminated wholly from the equation of college life. There is consolation to instructors in the thought, expressed by an able man, that "you can not by any scheme of education make anything of anyone and obliterate all trace of the natural character."

Abundant evidence is at hand to show the need of speedy and circumspect faculty action in putting wholesome restrain on student lawlessness. The press of the day is full of half-approving reports of the senseless pranks of college students. Recently, there came to my office a copy of The Courier, published in Geneva, New York, in which I read with much interest, a lengthy account of the dedication of a number of new buildings for the use of the New York Agricultural Experiment Station. The front page of the paper fairly overflows with reports of the idiotic doings of Geneva school boys and the wasted energy to be given by the students of Hobart College to a cane rush and football games. Not a word about the scholastic work of school or college can be found in these reports which appear in three separate columns of the page. That college work of any

desirable kind can thrive under such conditions is not in evidence. The air that is most popular with most students just now, and which indicates the direction of most student activity, is, "There'll be a Hot Time in the Old Town To-night."

COLLEGE ATHLETICS.

From what I have said under the head of "College Discipline," it will not be difficult to forestall much that I shall say, and might say, upon this subject.

Against the proper physical culture of college students, I have nothing to say. Most field sports are of value, if not pushed to an extreme. The manifest tendency, however, is to overdo matters and push athletics into the realms of professional sport. Possibly, I favor as strongly as any one the physical development of the race. A sound body is the proper receptacle for a sound mind. Emerson says that health is the best wealth. There is something of truth in the saying that the first thing one should do is to try to be a good animal.

The late war with Spain showed us the need of soldiers trained to great physical activity and inured to hardship. It also showed a need of discipline and an obedience to orders not the outcome of "football ethics." The swaggering air of ill-judged independence, so characteristic of some of our people went with our recruits to camp and battle-field. Undisciplined soldiers with false ideas of personal independence have brought brawl, riot, and bloodshed into some of our military camps.

It is discouraging to see our youth who, under our educational policy, enjoy exceptional opportunities for wisely fitting themselves for usefulness and honor hereafter, waste their time, fritter away their parents' money, weaken their moral growth, and suppress the promptings of their better nature in demoralizing sports, unmanly behavior, open-mouthed defiance of authority, and aping the swaggering habits of toughs and roughs.

In every student body, there are restless, lawless spirits, having the quality of leadership, who act as firebrands to inflame all the idle, vicious propensities of their fellows. Their presence in college halls is not for the purpose of acquiring scholastic training but to find a field for the play of their sporting tastes. The demoralizing influence they exert upon their companions is scarcely to be measured. They organize the forces unfriendly to studious habits; they stand in the forefront of all student escapades that bring just reproach upon our institutions of learning; they stamp the impress of their lawlessness upon the exercises of the athletic association; and there is never a revolt against decorum and decency with which they are not prominently associated.

The close observer of college life is forced to the conviction that the athletic association of every institution is its *storm center*. Many worthy students have membership in this organization, but their influence in its management is not very marked. The ostensible purpose of the association—the physical well-being of its members—is commendable. Most college students, particularly under the old-time idea of college instruction, need some kind of physical exercise to break the monotony of study hours and recitation periods. The value of the exercises of the gymnasium will not be diminished by the elimination of the danger element.

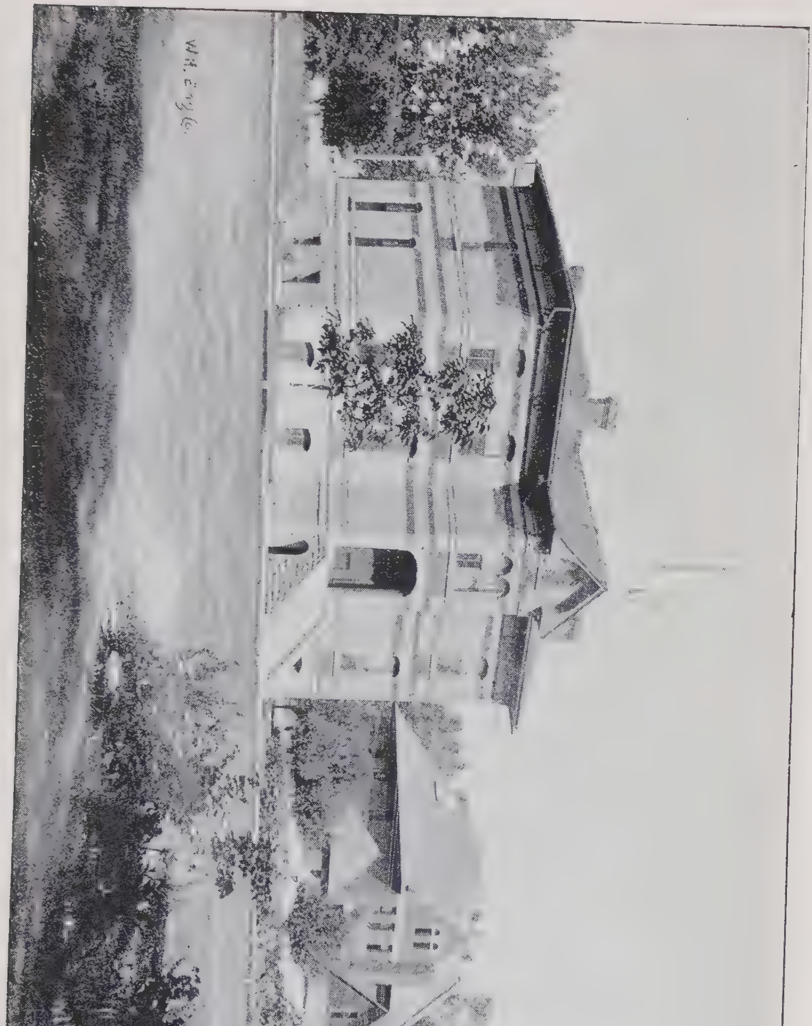
The last football season left a record of five deaths, thirty-three serious injuries, and minor accidents almost beyond computation. A newspaper writer, very friendly to the game, says, "The football season just closed shows more deaths and more serious accidents than any season in the history of the game." To weaken just condemnation of a game attended with such a number of casualties, the writer asserts that 25,000 players participated in the games during the season. Loss of life and permanent injury to body are bad enough, but they disclose but imperfectly the train of ills led by the "great game," as it is called.

I think that no one can make it clear that college athletics, as understood at present, secure any desirable development, physically, of those who take part in them. On the contrary, the strain they put upon the physical energy of the participants is so severe, at times, as to leave the bodily organism permanently impaired. Cases are not infrequent where football contests, on the "gridiron," have resulted in broken bones, over-strained muscles, and incurable bodily injuries.

Athletic contests are generally time-wasting, dangerous to life and limb, promotive of lawlessness, suggestive of brutality, and enervative of correct moral sense. If there is good in them it is deeply buried under the avalanche of bad. To say that good people give them a word of approval and countenance them by becoming their onlookers, is not to say that every rowdy, brutal, immoral, and idle element among the people does not find in them a source of keen, relishing enjoyment—something strongly appealing to that sense of pleasure to which alone their sensibilities are open.

The necessity for bodily exercise, training of the whole physical being systematically and regularly, has been admitted. The youth has animal exuberance that needs outlet. The direction of this virile force is of the utmost importance. The manner of its exercise must not bring undue physical exhaustion or any weakening of moral fiber. The country boy on the farm has about him the means of gaining bodily strength without any loss of intellectual energy or moral power. Work is an old-fashioned way of developing strength of limb and muscle.

There is a happy mean somewhere and college wisdom should seek to find it. The technical school, which has a scheme of instruction in which strength of mind and vigor of body come in daily contact, is one that promises some solution of the question that is prominent in educational circles—the education of the young from *all sides*. Open-air work, shop work, laboratory practice, engineering field work, and, above all, the military drill



with its strong, quick, graceful, and well-executed movements give the students fresh from scholastic work just what their physical nature craves and what will be of most service in its right development.

It would be well were our news reporters, instead of writing up the senseless and immoral pranks of college students in flippant style, as though right principles and public morals were not concerned in what transpires in school and college, to set forth in earnest words the lack of manliness and honor evinced by such reprehensible conduct. This course is rarely followed; and the failure of sharp newspaper rebuke encourages students of light brain power or those afflicted with "fatty degeneration of the conscience" to imagine that their foolish acts are the open sesame to public approval.

It is discouraging to the student of studious habits and earnest purpose, to see his idle, improvident, and lawless fellows lionized in newspaper paragraphs or pictured for the public eye, while his patient scholarly efforts whose success promises so much to his country, appear unworthy of casual mention. Some of the newspaper pictures of notable football worthies would prove a striking and an appropriate addition to the rogue's gallery. The young, unthinking and inexperienced in the just demands that society will make upon them, are prone to court this newspaper notoriety, seeing in it, under the flashy coloring in which it appears, the avenue to the attention and Godspeed of the public.

The football coach, is, in the false light reflected from college halls seen in gigantic proportions beside the gentlemanly, scholarly student who takes the highest honor of his class.

There will be a public awakening on this subject ere long; and the result will be the kindly, yet firm, repression of the objectionable features now connected with college athletics and an insistence, on the part of the college officials, that the young people under their direction give more wholesome and undivided attention to their legitimate educational work. Hazing, cane-

rushes, oratorical contests of shouts and yells, hand-to-hand conflicts between members of rival classes will be things forgotten or remembered but to flush the cheek with shame that they ever occurred.

MILITARY INSTRUCTION IN LAND-GRANT COLLEGES.

ARMY SERVICE OF COLORADO AGRICULTURAL COLLEGE STUDENTS IN THE WAR WITH SPAIN.

My approval of the military drill is as hearty as my disapproval of football, as played, is sincere. The military drill would be desirable, because beneficial, were wars and rumors of wars to cease. I know of no physical culture, outside of a well-ordered gymnasium, that is comparable with that of the drill exercise. On the drill ground, rather than on the "gridiron," can be found a place for "the cultivation and attainment of the better qualities of personal character such, for example, as courage, obedience, endurance, and regard for personal honor."

An oft-quoted paragraph of the first "Morrill Bill" contains one provision that makes it obligatory upon the authorities of the land-grant colleges to provide for instruction in military science. An amended act of Congress gives the President of the United States power to detail an officer of the Army or Navy to act as professor of military science in certain educational institutions having capacity to educate at the same time not less than one hundred and fifty male students. The number of officers thus detailed must not exceed one hundred and ten and the land-grant colleges are first to be recognized in making the details.

Prior to the war with Spain all the institutions given priority of details, as far as I know, had military exercises supervised by an officer of the Army or Navy. On the declaration of war, this officer was ordered to return to the service of the Government. At present I know not the status of the military work at the institutions affected by the order of recall but suppose

that it does not differ essentially from that existing in the institution I represent. The opening of the present college-year found two hundred and fifty male students, many wholly unfamiliar with any kind of military exercise, on our college grounds, and, in their organization into companies, I had no cadets of higher rank than sergeant available for service.

Lieut. Warren H. Cowles, 16th Infantry, was the first officer detailed by the President for service in The State Agricultural College of Colorado. Lieut. Vasa E. Stolbrand, formerly of the United States Army, preceded Lieut. Cowles as military instructor. Lieut. Cowles was succeeded by Capt. John C. Dent, 20th Infantry; he in turn by Lieut. Harry D. Humphrey, 20th Infantry, and upon the expiration of Lieut. Humphrey's detail, in the summer of 1897, Lieut. William C. Davis, 5th Artillery, became the professor of military science and tactics at the College. When war against Spain was declared, Lieut. Davis was ordered to rejoin his regiment, since which time the College Cadets have maintained their organization without the aid of an officer detailed from the Army.

Recently a circular letter, prepared by the Inspector General of the Army, was sent out, in which request was made for statistical information regarding the military service rendered by students and ex-students, of institutions whence officers had been recalled, in the war with Spain. If conditions generally were such as the Colorado cadets had to face, the history of the services of the students of the land-grant colleges in that war would be like the famous account of the snakes of Ireland—"There are no snakes in Ireland."

A portion of the circular referred to reads as follows:

"In order to determine the practical results of military instruction at the civil institutions of learning and with a view to further stimulate the military work conducted at these institutions, kindly fill up the inclosed blank forms and return one to this office."

"It is desirable that the information requested be given as fully as possible; and any further information or remarks upon the subject will be thankfully received."

The blanks referred to contain a series of ten questions designed to bring out full information regarding the military service of students and ex-students of the College in the late war with Spain.

As a matter worthy of more than a passing interest, I give, herewith, the full text of my reply to the circular letter.

To the Inspector General, United States Army, Washington, D. C.

Sir:—I have before me the blank forms whereon you request me to furnish statistical information regarding the military service rendered by students and ex-students of The State Agricultural College of Colorado in the late war with Spain. I have knowledge of four graduates and seventeen undergraduates and ex-students who were in the army after the war before named began. Herewith I give their names, and present rank and location as fully as information at present available will permit:

GRADUATES.

1. Archie Jesse Harris, (Fort Collins, Colo.) 2nd Lieutenant, 2nd Infantry, U. S. A., now at Montauk Point, New York. This enlistment was a result of the action of the War Department whereby students of meritorious standing in military service in certain institutions of learning were made eligible to a commission in the Regular Army.
2. Edgar Avery Mead, (Greeley, Colo.) Sergeant Co. D, 1st Regiment, Colorado Volunteers, now at Manila.
3. Richard Appleton Maxfield, (Rifle, Colo.) Sergeant Co. I, 2nd Regiment, U. S. Volunteers, Engineer Corps, now at Honolulu.
4. Grafton St. Clair Norman, (Hamilton, Ohio) 2nd Lieutenant Co. K, 8th Infantry, U. S. A., now at Fort Thomas, Newport, Kentucky.

UNDERGRADUATES AND EX-STUDENTS.

1. Frank D. DeVotie, (Greeley, Colo.) Sergeant Co. D, 1st Regiment, Colorado Volunteers, now at Manila.
2. Neil Carmichael Sullivan, Jr., (Longmont, Colo.) Sergeant Co. H, 1st Regiment, Colorado Volunteers, died at San Francisco, California, June 4, 1898.

3. John McMillan, (Fort Collins, Colo.) 7th Infantry, U. S. A., wounded at San Juan.
4. William B. Sexton, (Fort Collins, Colo.) Co. G, 20th Kansas Volunteers, Engineer Corps, now at San Francisco, California.
5. James Pullar, (Fort Collins, Colo.) Co. G, 8th Infantry, U. S. A., service at Santiago; three year term just expired.
6. Simon Moses Marks, (Buena Vista, Colo.) Co. F, 1st Regiment, Colorado Volunteers, now at Manila.
7. Joseph Clinton Holtschneider, (Buena Vista, Colo.) Co. A, 20th Infantry, U. S. A., was at Santiago; is now at home on furlough for sickness.
8. Francis Virgil Leroy McCandless, (Florence, Colo.) Corporal Co. A, 1st Regiment, Colorado Volunteers, now at Manila.
9. Perry Hjalmer Nyberg, (Pueblo, Colo.) Sergeant Co. A, 1st Regiment, Colorado Volunteers, now at Manila.
10. Robert James Potter, (Gunnison, Colo.) Co. F, 1st Regiment, Vermont Volunteers, at present at home on furlough.
11. John Thomas Richards, (Erie, Colo.) Co. F, 1st Regiment, Colorado Volunteers, now at Manila.
12. Benton Sylvester, (Berthoud, Colo.) 2nd U. S. Volunteers, Engineer Corps, now at Honolulu.
13. George Washington Springer, (New Windsor, Colo.) Co. D, 1st Regiment, Colorado Volunteers, now at Manila.
14. Everett Washburn Taylor, (Fort Collins, Colo.) Corporal Co. G, 1st Battalion, Wyoming Volunteers, now at Manila.
15. Fred Montgomery Westlake, (Florence, Colo.) Lieutenant 2nd U. S. Volunteer Engineer Corps, now at Honolulu.
16. Guy Surinus Hooper, (Greeley, Colo.) 2nd U. S. Volunteer Engineer Corps, now at Honolulu.
17. Henry E. Voegeli, (Cincinnati, Ohio) 1st Illinois Infantry, U. S. Volunteers, service at Santiago; now on furlough, Chicago, Ill.

Doubtless there are other ex-students who are enrolled in some branch of the army service, but information at hand does not give their names or location. This may not be regarded as a creditable showing for an institution in which compulsory mili-

tary drill, under an army officer detailed by the War Department of the Government, is required of two hundred and fifty students each day of the college-year. The military drill is an important feature of the work of the land-grant college as outlined by Congressional acts.

The detail of an army officer to fill the post of professor of military science and tactics in such an institution must be accepted as evidence of the importance of the military department therein as seen from the standpoint of the authorities at Washington. The military instruction and drill to which college students are subjected, under present regulations, are not designed, primarily, to foster a warlike spirit, but to afford a wholesome exercise whereby the bodily vigor of the student will be stimulated and conserved. The drill, as conducted, offers the young men of our educational institutions the best possible athletic exercise under conditions favorable to physical upbuilding and suggestive of permanent health. The thought of possible service in the fighting force of the Nation is not absent, but it is not the thought uppermost in the minds of those who conduct, or engage in, the military drill under normal conditions. When the blast of war blows in our ears, then it is natural to look to the young men trained in military science and tactics for loyal, patriotic, efficient service in the armies of the Republic. That such service was not proffered in larger measure by the students and ex-students of our institution is due to no lack of patriotism or courage on their part. These young people, without exception, are intensely loyal to their Government and under proper conditions would be among the first to respond to their country's call in time of war.

I regret to say that these conditions have not existed and do not now exist. At the first call to arms, Lieut. William C. Davis was ordered to return to his regiment and the College Battalion was left without an organizing and a directing head. This was not a move calculated to awaken and stimulate the military ardor of the two hundred and fifty cadets forming the three companies of the Battalion. The boys felt, perhaps without due consideration of all the conditions, that the Government had but little interest in the military work they had done, and were doing, and less call for any service they might feel prompted to offer. Some of them could look back upon five years of faithful service as members of the College Battalion, and at a critical juncture that organization had been practically ignored by the Government. If the late war, although making no great draft upon the

military resources of the country by reason of its short duration and the second-rate war power of the nation with which we were contending, shall better instruct those in authority, with us, how to utilize the military energy and enthusiasm of students whose college course requires attention to military study and the varied exercises of the drill, it will bring about a condition in our college life greatly to be desired. Under the new regime the officers of the War Department will have full power and ample means to put military instructions in our higher institutions of learning on a more efficient and a more enlightened basis. Then it will not be thought best to furnish grudgingly, and under useless and annoying restrictions, the various battalions of college cadets with out-of-date arms and equipments. The field pieces that lumber up our drill room or, when laboriously dragged upon the campus, excite the open-eyed wonder of small boys, will be retired from service and replaced with something less suggestive of Revolutionary days. Few of our cadets have ever seen, much less handled, a Krag-Jorgensen rifle.

The attitude of the War Department toward the college military drill is now one of "masterly inactivity," in which "how-not-to-do-it" is made conspicuously prominent. I have written two letters to the Department requesting information as to when to expect the detail of some officer to organize and direct our military work and have received nothing definite in reply. I have been forced to reorganize our military department with the highest officers available for help ranking as *first sergeant*. There are many retired officers efficiently serviceable for such work as is performed by a professor of military science and tactics in an educational institution, but I am not advised that any official attempt has been made to put them in charge of it. A letter from the Adjutant General's Office, of recent date, suggests that possibly the services of a retired officer could be secured by advertisement in the Army and Navy Journal, New York City, and the Army and Navy Register, Washington, D. C.

I have received information from a source somewhat distant from the War Department offices, that "no details whatever will be made till after the report of the Peace Commissioners." It is thought possible that this report may see the light of day about October 15. How doth hope deferred make the heart sick! The same mail that carried me that promise, whose fulfillment will doubtless project itself well into the future, brought your request for statistical information that will show the service rendered their country in time of war by our students and ex-students. A stream is not likely, by natural means, to rise above its source. I fear it will

be next to impossible to imbue our cadets with much of patriotic war spirit when so little concern for their growth in military experience and knowledge is shown by those to whom they look, with some right, for encouragement and help. I shall welcome the day when the military departments of our educational institutions are made highly efficient by reason of the hearty support and intelligent supervision they receive from the authorities connected with the War Department. Give the cadets every facility in the way of instruction and equipment that military experience can suggest and they will not be without military ardor or the power and will to give their country prompt and effective service in her time of need.

The opening of the late war found our male students prepared and eager for military service, but deprived of the commander who had brought their organization to a high state of efficiency. The Government seemingly had no call for their service as an organization or as a picked part of an organization. The only way open to our students, in their wish to serve their country, was in the complete disbandment of the organization to which some of them had belonged all through their college life and to which they were, with just reason, most strongly attached. If they turned to the state, in some hope that they would receive recognition from that quarter, they were told to wait until the mustering in of all divisions of the National Guard was completed and a place might be found for them in the ranks thereafter to be recruited. Meeting disappointment at every turn, they reluctantly gave over effort to secure recognition as a military organization. Those who enlisted did so on their own account, took pot-luck so to speak, and became tail-enders in some company whose efficiency as a military organization was not comparable with that which they were forced to abandon.

Some may say that patriotism should have prompted the boys to put aside the *esprit de corps* that so warmly attached them to their own organization and made them willing to pass down to the foot of some other one. Possibly had the exigencies of the Government, from the military side, been more pressing and urgent than they were, that course would have been uncomplainingly taken by our students, but the necessity for a disbandment of their organization to swell the membership of some other did not seem present. The officers of our companies had won their way to the front rank among their fellows by years of careful attention to, and pride in, the military drill. They were conversant with the manner and aims of military organization and were able to render what may not inaptly be called *expert*

service. Throw them out of their battalion organization and their military advancement is lost, and they must take places as privates in companies officered by persons of inferior intellectual and military education to themselves. It takes a strong patriotic force to push one out of a well-earned position of command into ranks filled up chiefly with men but little more than raw recruits. The graduate of a college who has won with honor and credit the epaulets of a commissioned officer may well be pardoned for showing some reluctance to entering upon a military life as "high private."

Had there been place for an organized body of our students in the line of troops, that place would have been occupied had it been pushed well up towards the nearest point of hardship and danger. It was not possible for the Agricultural College Cadets *to break into* the Army by all the push, personal, political, and official, they could summon to their aid. The recital of these facts shows why the College, with a large body of students and ex-students available for efficient service in the Army, can report but twenty-one representatives as placed where military service in their country's behalf can be rendered.

In connection with what I have written, I feel disposed warmly to commend that heading in the annual report of the Military Department of the College under which is given the names of three cadets of the graduating class who have shown the most proficiency in the military work. Following this, the recent action of the War Department in giving some thus selected for complimentary mention a chance to show fitness for a commission in the Regular Army, can not but be productive of good result. Now that a permanent increase in our national military force is almost an assured fact, would it not be well to make the selection of a few college cadets, of approved scholarship and proficiency in the military exercises, for suitable positions in the Regular Army a settled policy? Such recognition of deserving cadets, with the desire to follow the life of a soldier, would give an impetus almost beyond measure to interest in every phase of college military instruction. I can not but think that the army organization would be rendered more efficient by such an infusion of young virile force. There are some of our people who profess to see in the increase of our standing army a menace to personal rights and free institutions. This feeling will be materially weakened if people see important posts in that army filled by their sons and their neighbors' sons who have been educated in their home institutions of learning.

I wish not to widen the gap that now exists between the military organizations in our educational institutions and those whose movements are under the immediate direction of the War Department of the Government. On the contrary, I earnestly desire to see the existence of a closer bond of union between them. I would force no graduate or undergraduate into the Army. A craze to enter the Army in ordinary times, would indicate an abnormal, an unhealthy state of student life. There is no just ground to fear that military instruction in college, even on a much more wide-reaching and effective plan than that to which we have been accustomed will engender a blood-thirsty, war-at-any-cost spirit among students. I would not have a student prepared to serve his country in war hampered in his desire to do so by hard conditions and red-tape regulations. The Government provides for the military training, more or less effective, of a large student body. If war comes, and there is no opening in army ranks for these trained and scholarly young men, save in the lines of raw recruits, they may reasonably question the purpose of such prolonged and costly military training. There ought to be a ready place in our war forces for any well organized body of college cadets seeking active service and there ought to be no unnecessary obstacles placed in the way of their enlistment.

Let us have a more thorough management of the military work of the colleges in which military departments exist and a more ready means, in the war emergencies of the Nation, of utilizing the product of this increased efficiency of organization.

Respectfully yours,

ALSTON ELLIS,

President.

Fort Collins, Colorado, October 3, 1898.

When war with Spain was declared, a number of the college cadets, enough to form a single company, made tender of their service, with the single condition that their organization as such be accepted; but their effort to secure recognition was futile. That so many college representatives found active and honorable military service in the various volunteer forces of the country, is a testimonial to the unselfish and patriotic spirit prompted and strengthened by the military discipline and general training of the College.

The General Government has never given enough attention to the military organization at the College. The military authorities of Colorado have never manifested the slightest interest in it. While attempts of a vigorous nature have been made to organize companies of the National Guard in different sections of the State, a military organization large in numbers and suggestive of efficient service in war emergencies has been practically ignored by our state military authorities.

The neglect, to which attention is herein directed, is no matter of necessity; it is the outcome of choice—choice manifestly antagonistic to the spirit, if not the letter, of the law.

The three sections of the act of the General Assembly of Colorado, approved April 9, 1895, read as follows:—

Section 1. That, for the purpose of further carrying out the provisions of the act of Congress approved July 2, 1862, in relation to agricultural colleges, the military body known as the Agricultural College Cadets, of the Colorado Agricultural College, is hereby organized as an auxiliary branch of the Colorado National Guard, placed upon the same footing as regards arms, ammunition, clothing, camp and garrison equipage as the Colorado National Guard.

Section 2. That the proper officers of said Colorado National Guard are hereby authorized and directed to honor the requisitions of the commanding officer of said Agricultural College Cadets, under such rules and regulations as may hereafter be prescribed by the State Military Board and the State Board of Agriculture, when countersigned by the President of said college, for ten rounds of ammunition per year for each member of said military body, and for such camp and garrison equipage as may be necessary for the proper instruction of said body in all that pertains to the practical duties of soldiers in camp.

Section 3. The Cadets of the State Agricultural College shall be attached to the Colorado National Guard, under such rules and regulations as may hereafter be prescribed by the State Military Board and the State Board of Agriculture.

If this law is not intended to secure an intimate connection between the College Cadets and the National

Guard of the State, the reasons for its enactment are not readily apparent. It is desirable that early action to make effective the provisions of the law quoted be taken. A step in the right direction would be the issuing, under state authority, of commissions to the commissioned officers of the College Battalion. Then, such inspection of the military work of this organization, by the proper officers of the Colorado National Guard, as would show interest in its existence and approval of its purpose, should be provided for.

A larger regular army, for the wide-reaching service that lies just before the United States, is now recognized as a necessity. Competent military authorities maintain that the great need in army circles will be an increased body of well-trained, scholarly, serviceable officers. The General Government can widen the work of the National Military Academy and, in time, supply the Army with the required number of trained officers, or it can establish new military schools and thus bring about the same result; but both plans suggest great expense and are wholly unnecessary. By the endowment of the land-grant colleges, by requiring instruction in military science and tactics to form a part of their work, and by the detail of army and navy officers as instructors in them, the Government has placed thousands of its able-bodied young men—picked men as to native and acquired ability—in a position to receive that military and scholastic training that makes the best equipment of an army officer. In every college, in any way subject to the control of the Government, there are a number of lusty, energetic, patriotic, and intellectually-trained young men who have an enthusiastic desire for a military life. This desire on their part is not unnatural, merits no strong repression or stern rebuke from any quarter. All over the country aspiring young men are seeking, with avidity, cadetships at West Point and Annapolis and, in their efforts for such appointments, are receiving the active support of their friends and the hearty approval of the public. The conditions about the land-grant college are

such that the right preparation each year of a limited number of students for commissions in the regular army would bring nothing in the way of extra effort or expense to the institution. The colleges of the United States to which military officers are now detailed, as instructors, can, annually, direct towards the permanent military organization of the country several hundred young men worthy to hold rank as commissioned officers, and that, too, without additional drafts upon either state or national treasury. Were the annual selection of two or three college cadets, of strong inclination and special aptness for military life, as commissioned officers in the Regular Army, made an assured fact by action of the Government, a strong impulse would be given to every phase of our military work. Thus would the military needs of the Army, in the way of well-equipped officers, be easily, inexpensively, and effectually met.

FUNCTIONS OF THE LAND-GRANT COLLEGE.

I purpose under three heads, of which the one found above is the first, to give an exposition, as full as may be presented in the limits of such a report as this, of what a land-grant college is and the kind of educational work it can legitimately undertake.

It would seem, at first view, that there ought to be no difficulty in rightly interpreting the provisions of the Congressional acts of 1862 and 1890. The first includes eight sections and the second, five—none of great length. Look at the names of the institutions that are beneficiaries under said acts, and the conviction is forced upon you that those who control them are far from having a common understanding of the amount and character of the educational work for the promotion of which the "Morrill Bills" were framed. The author of those measures has been called upon time and again for an expression of his purpose in their preparation. He has uniformly asserted that the acts were designed to meet the educational requirements of the millions engaged in industrial pursuits. He has affirmed that the term

"Agricultural College" as applied to the institutions, established under the acts of Congress before referred to, is a misnomer and not suggestive of the *liberal* education of the industrial classes.

The name "College of Agriculture and Mechanic Arts" comes nearer to expressing the purpose of the "Morrill Bills," as far as that purpose can be determined from their wording, than does the term to which Senator Morrill so strongly objects.

There are some points that, to me, seem clearly established. Congressional legislation never contemplated any general duplication of existing institutions. No one can find in any part of the "Morrill Bills" any authority for the establishment and support of schools exclusively for "agriculture" or the "mechanic arts." No narrow, one-sided, technical school is authorized anywhere in the bills to which reference has been made. The teaching of trades, the forcing to farm labor, and the neglect of the cultural in education can find no authorization in the broad and liberal provisions of these enlightened measures.

It is unfortunate, in many ways, that the name "Agricultural College" has been fastened upon so many of the institutions partly endowed by acts of Congress. It may be doubted whether the appellation "Land-Grant College" suggests anything of the nature of the educational work of these institutions. As long as they are called "Agricultural Colleges," "Agricultural and Mechanical Colleges," "Industrial Universities," and names equally significant, it is reasonable to expect the general public to have erroneous ideas of their legitimate work and aims. What more natural than to expect and require an agricultural school to teach *agriculture*, and but little else? If an industrial university is not to teach all the trades—prepare for all the vocations in which physical energy is employed—people are led to say "what's in a name"? The people who have to deal with an "Agricultural College" are not wholly to blame for the persistence with which they hold to the opinion that its mis-

sion, in the educational world, is to give that practical training that will best fit one to become a farmer or a mechanic. In many cases appeal has been made to law-making bodies for financial support with arguments tending rather to strengthen than to weaken this narrow and illiberal view.

The common opinion of what a college founded "for the benefit of agriculture and the mechanic arts" should do is expressed in the questions that come from some self-named practical man who professes to believe that the less education one has the better fitted he is for labor on the farm or in the shop.

The head of an agricultural college is asked how many farmers' sons seek his institution for educational advantages and how many of these, after a period of college training, return to the farm? A few quotations from a reply I once wrote to a series of such questions may find an appropriate place in this connection.

"The writer of the queries forgets, seemingly, as many others forget, that the land-grant institutions are not exclusively agricultural schools, although some of them are operated under the title, 'Agricultural College.' It is well to keep in mind the scope of the Congressional act of 1862, under whose wise and liberal provisions more than sixty scientific and technical schools, 'to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life,' have been established."

"In no part of the various provisions found in the Congressional acts of 1862 and 1890, better known as the 'Morrill Bills,' can the word '*agriculture*' be found out of immediate connection with the terms '*mechanic arts*.' The just conclusion is that the so-called land-grant college is as much an institution for promoting education in the mechanic arts as in agriculture. A clear understanding of this fact will weaken the force of much criticism upon the work and the products thereof, of the land-grant colleges. All these institutions of learning—they are such, not merely little, narrow, one-sided schools of agriculture resting upon a shallow scientific foundation—have, or ought to have, under the requirements of the Congressional acts, courses of study making adequate provision for instruction in 'agriculture and the mechanic arts' and such branches of learning, including the clas-

sics, as are related thereto, and properly suggesting a 'liberal and practical education.' "

"I have not a wide range of statistics at hand to support my opinion that the work of the agricultural college is becoming a strong force to popularize and make more remunerative all phases of labor connected with farm life."

"There are strong influences tending to counteract this good work, and these influences are thrust through college doors into college halls by farmers themselves. Only yesterday, a farmer of more than average thrift and intelligence, brought his seventeen-year-old boy to my office to arrange for his admission to college. In the boy's presence he stated that his purpose to have him enjoy the advantages of the institution was born of a desire to have him get a living by some easier, surer, and swifter process than farming. Are there not many such farmers in the land? I venture to say that the larger number of farm people who send their sons and daughters to the agricultural colleges do so in the hope of freeing them from the necessity of the slave life of labor, as they call it, through which they passed to the creature comforts they now enjoy. These comforts are too plain, too every-day, and too little suggestive of social dissipation to satisfy wants that have grown abnormal under the promptings of the restless, uneasy, dissatisfied spirit all too common among our people. Then, too, people want to get rich fast and are not always choice as to methods. No wonder that under such home influence the boy grows into the belief that an education worth having should bring its owner the maximum of pay with a minimum of effort."

"The college in which science is taught practically, where technical work is wisely planned and made an every-day exercise, is doing more to make toil respected than the farm home presided over by parents who teach their children to look upon an education as the 'open sesame' to a life in which the work grows lighter as the pay becomes greater."

"Even the graduate from the agricultural course of a college is not always to be blamed for not throwing himself with spirit into the usual current of farm life. There may be no farm to which he can profitably return. That of his father, it may be, is under full tribute to support the stay-at-homes. The son with a college training, costing some years of effort and a snug sum of money, naturally rebels against entering into the labor and compensation of the average farm hand of the push-and-pull, fetch-and-carry order. If the possessor of a college diploma can direct, with advantage to all concerned, the operations of an extensive

irrigation system, why ask him to pull on a pair of irrigating boots and irrigate the crops on some land-owner's farm at $25 per month and board? If an education fits one to earn $100 per month, why find cause for criticism because he is unwilling to engage in a more uncongenial labor for much less pay? What kind of service from the agricultural college graduate is it reasonable to demand? The one capable of directing aright the labor energy of a number of employés, in any branch of productive industry, is giving better service than he could render under the condition of the average laborer."

"It is too soon to declare without qualification the success or failure of the agricultural college in industrial fields, be they urban or rural. Some of the operations of this new educational agency are in a tentative state and further data are needed before safe conclusions are reached. I believe it is true that most educational agencies outside of the land-grant colleges and technical schools have little thought about the farmer and the needs of his children as the farm people of the future. The traditions of the old-time college, with its classical course and exaggerated ideas of the value of a professional life, are against any mode of securing a livelihood outside of an office. There is hope for better things under the new educational regime which recognizes the dignity of manual labor and professes to fit for it by special scientific and technical training. The educated man is always best equipped to meet the problems of life."

I have already expressed my belief that the institutions established under the provisions of the "Morrill Bills" should form a distinct link in the educational chain. The author of the law of 1862 has said that when he introduced that measure into Congress, the colleges and universities of the country were giving an education designed exclusively for the so-called learned professions, with nothing to meet the pressing requirements of the members of the great working bodies of the people. Then, in the framing of the law with which his name is so honorably connected, he could not have contemplated an addition, in kind and method, to the very institutions he felt had ignored the educational needs of the industrial classes. The "Morrill Bill" of 1862 was not designed so much to strengthen any existing educa-

tional institutions as to found, and to provide an endowment for, a wholly new one—one that in its work and aims should pretty clearly differentiate itself from colleges and universities as they then existed. It may be admitted that there is argument for teaching almost anything to be found in the latter portion of section four of the Act of 1862. It is hard to believe, however, that the founding of a new college or university along the then established lines, or the financial strengthening of some institution for higher education that had "given little or nothing to the requirements of the millions engaged in industrial pursuits," was the motive that prompted Congress to pass that law. The trouble is that college men interpret the educational clause of that measure to support their own views or to defend the environments wherein their professional efforts are exerted.

When the first "Morrill Bill" became operative, there was hardly a state college or university in the country that did not make effort to secure recognition under its provisions. The fact that such institution, by reason of its lines of study and deep-seated traditions, was almost wholly unprepared for the new work and out of all vital sympathy with it, was no hindrance to effort on the part of its authorities to secure its further endowment at the expense of the fund established for the "liberal education of the industrial classes."

It is worthy of note that the word "*university*" nowhere appears in either of the "Morrill Bills." Wherever the institution to be established, or further endowed, is referred to it is termed a "*college*." We recognize a clear-cut distinction between the terms, as did, doubtless, the author of those measures and others who supported them. Plainly, in my view, the "Morrill Bills" were designed to establish and endow new institutions whose aims, methods, and activities should be a wide departure from those then in vogue in the colleges and universities of the land. The new institutions, in their work, were to keep prominently in view instruction that

would further the advancement of agriculture and the mechanic arts. Other scientific and classical studies, not closely connected with the *main end* to be advanced, were not necessarily to be excluded from their courses of study, for, with all the special training for definite ends held of first value, the liberal culture of the students was considered desirable. That some associate anything designated *liberal culture* with the study and mastery of the classics—Greek and Latin—is a fact that has no vital connection with the question now under consideration. There are some who are just as pronouncedly of opinion that all we call culture, in the realms of mind and morals, is not reached by winding through the intricacies of Latin construction and delving into the mysteries of Greek roots. Even some of the abstractions and mystifications connected with the study of what is rather indefinitely called, "*philosophy*" might be omitted from the course of the land-grant college without serious loss to the culture and training of its students.

However wide and liberal, in the interpretation of some, may be the provisions of the first "Morrill Bill," there is no mistaking the fact that pretty definite metes and bounds are set to the educational work of the land-grant college by the terms of the second. Herein it is expressly stated that the more complete endowment and support of the college for the benefit of agriculture and the mechanic arts shall "be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to the industries of life." Evidently the thought connected with this language is that a liberal education for the man of affairs has some connection with close, student contact with the lines of study thus specifically stated. Did the period that spanned the dates 1862 and 1890, bring a revolution of opinion as to the work proper for a land-grant college to enter upon, or are we to regard the later

expression of the will of the law-making power but as an interpretation of what went before?

There is a link that binds these two dates and the provisions of the Congressional acts connected with them. The act of 1887, known as the "Hatch Act," connects a department, to be known as an "Agricultural Experiment Station" with each land-grant college, then established as the result of former legislation, under certain minor conditions that state legislative power may impose. The evident intent of the "Hatch Act" is to give stronger and more practical impulse to the agricultural work of the land-grant college.

As a result of some of the facts recited—in view of *all* the legislation of Congress bearing upon the establishment and support of colleges for the "benefit of agriculture and the mechanic arts"—a few conclusions seem warranted:—

1. The state that has established *one* college for the benefit of agriculture, etc., and that wholly disconnected with any other educational institution, has followed closely in the path marked out by Congressional legislation.

2. The course of that college, if it make *prominent* instruction in agriculture and the mechanic arts, is in prime accord with one of the most important provisions in each "Morrill Bill." To profess to teach branches *related* to agriculture without teaching the subject itself is, to me, sheer nonsense.

3. Although special prominence should be given to the subjects before named, other studies designed to broaden and discipline the mind of the student—to fit him for intelligent helpfulness in affairs of society and state—should find a place in the course of study offered by such college. These studies should be such, in the main, as articulate most closely with those already named and engender a trend of thought and effort most in harmony with the ideas underlying the promotion of industrial education generally.

4. A course in domestic science, one for a business department, and under-graduate or post-graduate courses in engineering—civil, mechanical, and electrical—are not out of place in the exercises scheduled for the college.

5. The work of a school of mines has no intimate connection with that of such a college as has been referred to; but inasmuch as its general aim is to make more effective an important phase, in certain sections of the country, of industrial life, its incorporation with that of the land-grant college would not be at variance with the general purport of existing legislation and, in a state where mining is one of the leading occupations of the people, might be strongly in the interest of economy.

6. Instruction in military tactics is a part of the prescribed work of the institution receiving financial support from the General Government. The land-grant colleges are first served in the authorized details of officers from the Army and Navy to serve as professors of military science and tactics in educational institutions. The requirement is recognized by all the colleges affected; but there are different ways of rendering such requirement effective. The letter and spirit of the law ought to be obeyed and all able-bodied male students should be held rigorously to a reasonable amount of military service.

STATE AND COLLEGE.

The relation of the *state* to the land-grant college has not been a subject of much discussion in circles touching the work of the institution. The work of the college will depend almost wholly upon the manner of its organization under state authority and the local interpretation of the provisions of the "Morrill Bills."

The financial provisions of the original act have given some land-grant colleges a permanent endowment from which they now receive a large annual revenue;

others derive but a slender revenue from that act. State equality in sharing in the endowment fund created by the act of 1862 was not secured by reason of the fact that the amount of land apportioned to each state was determined by the number of representatives in Congress to which it was entitled. This worked to the disadvantage of the newer and smaller states. All states are put upon an equal footing, as to government financial support, by the conditions of the act of 1890. No discrimination against a small state is seen in the apportionment of the fund for the support of the experiment stations.

Uniformity in nature and scope of the work of the land-grant colleges is impossible so long as the various state and territorial governments place their own interpretation upon the language of the Congressional acts. One state begins with an agricultural and mechanical college and later on converts it into a state university with courses of study in conformity with the new title. Another finds a full compliance with the acts of Congress in creating a college of agriculture in connection with some existing institution. Some provide one course of study; others a number of courses. Money for the support of all this varied work is taken from both government college-funds, save that language instruction other than English is not paid for from any appropriation authorized by the Act of 1890. In many states, the appropriation from the state treasury for college support exceeds that received by the institution from the United States treasury. The state in such cases, at least, can justly claim a controlling voice in the managerial policy of the institution within its borders. Then, it must not be forgotten, that the purpose of the "Morrill Bills" is not *unduly* to influence action favorable to the development of certain phases of higher education, thought desirable and serviceable, within the states. No state is forced to accept the bounty of the Government whereby the better education of the industrial classes is sought to be conserved. The people of this country have been taught by the logic of events to

look with disfavor upon any governmental policy smacking strongly of paternalism.

The authorities who have the general supervision, in the name of the Government, of the funds set apart for the maintenance of the sixty institutions, or more, founded under the acts herein so frequently named have ever shown a disposition to recognize state control over them as final to the fullest extent consistent with a very liberal interpretation of the law. Commissioner Harris, of the Bureau of Education, states the guiding principle governing the acts of the officials referred to when he says, "This office has no desire to go behind the returns; and, except where it is evident that a misstatement has been made, the reports of the treasurers are accepted as rendered."

When certain lines of study are specified in the Act of 1862, it is at once added that the instruction shall be given "in such manner as the legislatures of the states may respectively prescribe." It is taken for granted that each state will use its own legislative judgment in the matter of founding the college and organizing its work. The action of the legislature of Colorado, in making acceptance of the terms of the Act of 1862, in the name of the State, is, I believe, a type of what is best in this class of legislation. A portion of an act approved January 27, 1879, reads as follows:

> "Whereas, The State of Colorado has constructed and provided for the support and maintenance of an agricultural college within its limits * * * that in conformity with an act of Congress of the United States * * * assent is hereby given to the provisions of said acts and amendments thereto, and the grants mentioned in said act are accepted, with all provisions connected therewith."

After the passage by Congress of the Act of 1890, legislative action in Colorado, making full and complete acceptance of its conditions, was coupled with the following authorization: "That the State Board of Agriculture shall have the control of the fund appropriated

by the said act of Congress, and shall disburse the same for the use and benefit of the State Agricultural College, in accordance with the terms and provisions of said act of Congress."

These acceptances did not terminate legislative action relating to the management and support of the college. A tax of one-fifth mill on the assessed valuation of property within the state was authorized, special appropriations for buildings were voted, and laws creating a governing board and, in general, defining its duties were enacted. In referring to Colorado, in these particulars, I am calling attention to no isolated case. There is not a state in the Union that would not maintain its right to legislate, almost without restriction, upon matters connected with its college "for the benefit of agriculture and the mechanic arts;" and, in so doing, there would be no great likelihood of a misunderstanding or conflict with the Washington officials.

The fact that the state is the active, right-at-hand agency for directing our college work, is a sufficient explanation of the different forms that work assumes and the diverse views sometimes entertained by college representatives regarding it. College men, may consider, discuss, and argue until they reach an agreement—were that possible—as to what the land-grant college should do and should not do, yet that agreement must find expression in the laws of the various states before it can be made forceful in changing, to any great extent, college management. Primarily, the Congressional acts suggest certain lines of work with more or less definiteness; ultimately, legislative enactments in the states close the question against all but local debate. A college preparatory school is a necessity, if the standard of scholarship for entrance to the college is too elementary in consequence of legislative action. Left to act upon my own judgment, I would not make admission to the institution with which I am connected as easy as it is now. I think a pronounced vote of land-grant college men would favor raising the standard of scholarship all

along the lines of educational effort with which they come in touch. Most of them feel, doubtless, that their work suggests specialization of effort on the part of students too soon and that a fairly broad foundation of general scholarship should underlie the attempt at specialized effort in every field of human activity. They may agree upon these things in convention, but unanimity of opinion among them does not change the necessity for obeying the law at home. "Good thoughts, though God accept them, yet toward men are but little better than good dreams unless they be put in act."

PURPORT OF THE CONGRESSIONAL ACTS OF 1862 AND 1890, BETTER KNOWN AS THE "MORRILL BILLS."

QUOTATIONS SHOWING THE BEST INTERPRETATION PLACED UPON THE EDUCATIONAL PROVISIONS OF THOSE ENLIGHTENED MEASURES.

It is now more than thirty-six years since the first bill for establishing and endowing a "college of agriculture and mechanic arts," in the several states and territories of the Union, was enacted into a law by Congress. Since then more than sixty institutions of learning have been established under the liberal provisions of that wise and beneficent measure. These institutions while having a general aim, pretty well defined, vary greatly in the amount and kind of work upon which student activity is exerted. The trend of educational effort in most of these institutions is towards a more liberal culture of students—a higher standard of scholarship—and a training that will later place the student in more helpful contact with the great and diversified industrial interests of the country.

The information, regarding the workings of these new educational agencies, most needed by the people, is that which will bring clearly to their minds the paramount objects for the accomplishment of which these institutions were established and the legitimate means to be employed in the attainment of these aims. As an

interesting and instructive addition to this field of thought and discussion, briefly stated views of some eminent for service in the cause of popular education are herewith given.

In speaking of the educational significance of the movement that resulted in the establishment and endowment of the land-grant colleges, in an address delivered at the Massachusetts Agricultural College in 1887, Charles Kendall Adams said:—

"It opened the whole realm of nature as the legitimate field of investigation and study. Before this time the work of the schools and universities had been confined to developing the minds of the pupil and the teaching of the four learned professions—theology, medicine, law, and pedagogy. Universities had been established in the twelfth, thirteenth, fourteenth, and fifteenth centuries in all parts of Europe, but in no one of them were studies carried on in accordance with the modern investigating spirit."

And, again, in closing his address, he makes use of the following language:—

"These are some of the lessons and some of the necessities that are taught by experience; and yet they are only hints, as it were, designed to show how vast is the domain that invites the careful study of our schools and colleges. It is into this domain that the people were invited by the wise Land Grant of 1862. It is in this domain that the colleges and universities founded on that grant, if they live up to their high behest, will accomplish results that shall be for the helping, if not for the healing of the Nation."

Hon. Justin S. Morrill, whose honored name is inseparably connected with the Act of 1862, the *first* "Morrill Bill," followed President Adams in a striking address from which the following excerpts are taken:—

"The existence of the colleges can alone be vindicated by reason that they are not superfluous but indisputably wanted; and that their work is not Utopian but practically of real service to the country. * * * The importance of long terms of human training for the professions of theology, law, medicine, and peda-

gogy, has for years been held to be indispensable. But these learned professions, important as they are, numerically include only a small fraction, comparatively, of the human race; and, yet, it is hardly too much to say, that our ancient colleges and universities mainly provided instruction originally intended exclusively for those who sought to be equipped for these special classes. The great majority of mankind, therefore, lacking perhaps neither ambition nor native ability, were dependent upon the hap-hazard of self culture, or upon being taught in some brief way in the district school how to read, write, and cipher. If this uncounted and unrepresented multitude sought to acquire knowledge of more practical value in the voyage of life, they soon found that useful knowledge was often estimated in ancient and richly endowed institutions to mark the humble station of steerage passengers, while the august institutions assumed to provide alone for passengers in the cabin, and, for them—having reluctantly abandoned the discipline of the 'birch'—only an intellectual discipline, the efficacy of which no one disputes, though no less efficacy may be claimed in behalf of studies for scientific use than for classic ostentation. * * * The great army of industrious laborers in the field and workshop, in mines and factories, or on railroads and other business enterprises—ready at any time to give their lives in support of the liberties and union of the Nation—had some right to more of sound and appropriate learning that would elevate and especially profit them in their respective future careers."

"The school age of man is far too brief for the acquirement of all knowledge of philosophy, letters, and science, and where the dead languages have the primacy, there is little chance for the sciences, for modern languages, or even for our native tongue, or, indeed, for much, with scholarly thoroughness, in anything else. A mere smattering of the sciences, or of the ancient languages, is no more to be coveted than even the old absolute *unity* of all college education. The organic law of the land-grant colleges, therefore, made it a leading feature that instruction should be provided, *without ostracising anything*, in branches related to agriculture and the mechanic arts, upon which, as we all know, the greater number of mankind must rely for their subsistence and happiness, as well as for their growth and reputation among men."

In the quotation last given the italics are my own. The words are deeply significant of what was in the

mind of Senator Morrill when he introduced into Congress the first measure that is best known by its author's name. The whole address from which these citations are made is a strong plea for industrial education in which the practical and cultural elements shall be happily blended. There is not a sentence of Senator Morrill's utterances, at the time named, that is not in fullest accord with the opinions expressed in the brief quotations given. Ten years later, 1897, Senator Morrill writing, from the Senate Chamber, Washington, D. C., to Director True, of the Office of Experiment Stations, United States Department of Agriculture, says:—

> "I have to say that the Act of 1862 was intended to give those whose lives were to be devoted to agriculture or the mechanic arts, *or other industries*, embracing much the largest part of our population, some chance to obtain a liberal and practical education. The colleges in existence did not pretend to do anything more than to educate young men for the three professions of divinity, law, and medicine and surgery."

Again I take the liberty to italicize three words in the quoted extract.

At one time it was proposed to make the Agricultural College of Massachusetts a "living branch" of Amherst College. The latter institution was, doubtless, in need of a "living branch;" but the state's obligation to the masses of the people, and to the General Government as well, would have been imperfectly fulfilled had the proposed union of the two institutions been consummated. Hon. Charles G. Davis, who gave a masterly historical address on the occasion twice before referred to, had this to say of the proposed connection of the institution authorized by the Act of 1862 with the classical institution at Amherst:—

> "I have never been able to see how the state could 'support and maintain' a college if it is made an annex to another college. How can the state send its Board of Agriculture as overseers to another corporation? 'At least one college.' If an agricultural college, so-called, is located in the vicinity of another college, it

still can not be another college, unless it rests upon a separate foundation, with independent and distinct professors throughout; and, if so, there can be no saving of expense by any such conjunction as can be made under the law."

The following tersely expressed opinion of the best reason why the farmer's son should go to the land-grant college, is from the pen of Dr. A. C. True, whose efficient labors have done so much to promote the value of experiment station work in the United States:—

"The boy does not go to an agricultural college to practice the ordinary operations of a farm as a means to provide support for his schooling or simply to learn the art of agriculture. He is to be taught not only how to do things, but why he should do them, and he should be so taught that when his college course is over, he will not be merely familiar with the ordinary routine of farm work, but will be able to plan such work in a progressive way, to take advantage of all that can be learned from the investigations of experiment stations and other scientific institutions working in behalf of agriculture, and to direct the labor of others in the most approved and profitable way. Not only must the agricultural college supply the demand for trained managers of our larger agricultural industries, but it must also train men for positions in our experiment stations, colleges, and in that increasing number of industries related to agriculture where scientific training is necessary to the highest success."

The proceedings of the College Section of the Association of American Agricultural Colleges and Experiment Stations, at the tenth annual convention of that body, held in Washington, D. C., in November, 1896, were marked by the presentation of a number of papers on the question, "What shall be taught in our colleges of agriculture?" G. T. Fairchild, then President of the Kansas Agricultural College, opened the discussion by reading a paper from which a few characteristic extracts are taken:—

"Unless the colleges of agriculture reach a considerable body of farmers with their liberalizing education there is little hope for a scientific agriculture. * * * It is absolutely essential that the way from the farm to the college shall not be interrupted.

The city high schools do not and can not furnish the true line of training for the farm boy whose every sympathy is in the field and forest and farmyard. The trend of secondary schools is almost universally toward the need of the city in merchandise, manufactures, and professions. * * * As fundamental in all study, a thorough training in the English language must stand first. If this is given through a comparison with other tongues I shall not complain, but the result must be English rather than linguistic information or grammatical expertness."

Then in order of importance as he sees it, President Fairchild names "an exacting study of mathematical principles and distinct application of these in quantitive sciences like chemistry and physics," the "descriptive sciences and the philosophies of organic life," the "art of expression," and a "training in manual dexterity."

President H. H. Goodell, of the Massachusetts Agricultural College, spoke, in part, as follows:—

"More mind and less muscle is the watchword of to-day. In preparing the soil, in planting, in cultivating, in haying, in harvesting, in threshing, in the management of the dairy, in fact almost everywhere, intelligence is the principal thing, and mere brute force comparatively worthless. * * * The curriculum naturally divides itself into seven departments—the English, the agricultural, the chemical, the botanical, the mathematical, the zoölogical, and that of languages and social science."

H. J. Waters, Director of the Missouri Experiment Station, followed in the discussion and made the following statements, among others:—

"It is clear that no definite scheme of studies equally applicable to the needs and requirements of all states and to the peculiarities of the public and high-school system of the different states can be laid down. Nor is it, in my judgment, possible, except within very wide and general limits, to say what shall be and what shall not be taught in our agricultural colleges. * * * It appears to me to be a matter for each college to determine for itself whether it will attempt to take cognizance of all the important industrial interests or concentrate its efforts and funds upon a few of the more important ones. As to whether a given college shall offer courses in agriculture, mechanical, mining,

civil, or electrical engineering, and domestic economy, or require all its students to pursue one course embracing the leading educational and industrial features contemplated in the law should be left to the properly constituted authorities of that college to determine. * * * By the letter of the law there is no restriction as to what the cultural subjects shall embrace—whether the classics, modern languages, psychology, or what not. While it is agreed upon every hand that in all cases provisions should be made in all courses for a reasonable amount of instruction that tends toward liberal culture, it is equally clear that the technical, the industrial, the useful instruction (those sciences relating to the several industrial pursuits) shall constitute the majors, in order that the training there imparted may be directed to some practical end."

H. C. White, President of the Georgia College of Agriculture and Mechanic Arts, emphasized much that had already been brought out in the preceding papers, in his address from which quotation is herewith made:—

"Our institutions are to be educational establishments, not professional schools. They are to contribute to the drawing out and direction of the intellectual powers of the youth of the land—particularly of the 'industrial classes'—so that they may be properly fitted by 'liberal and practical' culture to engage in the 'several pursuits and professions of life.' * * * There is no warrant in law, or reason, for the distinctive designation of our colleges as 'agricultural' or 'mechanical.' I think it is a pity that the habit has grown among us. 'Land-grant' or 'State,' or 'Science,' would be more fitting appellations if distinctiveness is desired."

The Act of 1862 "was intended to increase the learning of the youth of the land, to furnish them with intellectual powers and stores of knowledge applicable to industrial pursuits by providing liberally for the education, to that end, in order that, those who might engage in such pursuits should no longer be mere slaves of craft, but freemen in the intelligent prosecution of their chosen handiwork. * * * So far as the letter of the law is concerned, the strictest constructionist could not assert that anything having the faintest shadow of a claim to be considered a branch of education might not be taught in our colleges."

The twelfth annual convention of the Association of American Agricultural Colleges and Experiment Sta-

tions was held in Washington, D. C., November 15, 16, and 17, 1898. The address of the President of the Convention, Henry C. White, Ph. D., of Georgia, contained statements interpretative of the acts of Congress relating to the land-grant colleges. The address was referred to a special committee, composed of George W. Atherton, LL. D., President of the Pennsylvania State College; J. E. Stubbs, LL. D., President of the Nevada State University; R. H. Jesse, LL. D., President of the University of Missouri; Enoch A. Bryan, A. M., President of the Agricultural College and School of Science of the State of Washington; and J. K. Patterson, LL. D., President of the Agricultural and Mechanical College of Kentucky.

In its make-up, the committee represented every phase of educational work operative within the land-grant colleges. Its report, which is an authoritative affirmation of the statements contained in President White's address, is as follows:—

"The brief time which could be given to a proper consideration of the address, in the midst of many pressing engagements, precludes the possibility of doing more than to express a general but unqualified assent to the views so ably set forth by the President of the Association; and the Committee submits to the Association, without argument, the following resolutions as a brief expression of its views and as a platform upon which the institutions here represented may confidently take their stand."

"1st. That the proceeds of the United States Land-Grant Act of 1862 and the annual appropriations provided for by the Acts of Congress of 1887 and 1890 are a National Trust to be administered by the several states in strict accordance with the letter and spirit of the grant."

"2d. That the land-grant colleges, whether organized separately or as branches of state universities, are primarily educational institutions required by law to teach certain branches of learning."

"3d. That these branches of learning are to be taught with special reference to their applications in the industries of life."

"4th. That this requirement involves a thorough fundamental training in the principles of the mathematical, physical and natural sciences, in order that their practical applications may be

DOMESTIC SCIENCE BUILDING.

clearly understood, and forbids that the institutions shall in any way be regarded as *trade schools*."

"5th. That the land-grant colleges are required by law to provide a *liberal* as well as a *practical* education, and that it is therefore their special duty to study, practice, and develop sound principles of instruction in the teaching of all branches of learning both liberal and technical, to the end that the subjects taught may be made the means and instruments of a true education, as well as a means of acquiring a body of concrete knowledge."

"6th. That the aim of all research shall be to learn the truth, and the aim of all teaching, to teach the truth and nothing but the truth; and that, to this end, freedom of research and freedom of teaching are indispensable."

"7th. That all teaching should accordingly be absolutely free from partisan or sectarian bias, that the institutions should be free from partisan or sectarian control, and that no interference in the administration, or in the teaching, or in the tenure of office should be allowed on partisan or sectarian grounds."

The opinions that the foregoing quotations present vary in degree, but not in kind. The consensus of opinion, regarding the necessity of a broad, generous literary culture, growing out of the instruction and training given the students of the so-called land-grant colleges, is very marked. Conditions in Colorado are very favorable for the realization of all that is best and most progressive in the Congressional legislation, assent to which, coupled with wisely ordered legislative action, has given our state a college that stands well up to the front among the institutions of its class.

CONCLUSION.

I have purposely made this report more comprehensive than usual. In its preparation, I have not hesitated to quote liberally from my recent report to the State Superintendent of Public Instruction and my address, as Chairman of the College Section, delivered before the annual convention of The American Association of Agricultural Colleges and Experiment Stations that met lately in Washington, D. C.

The College is now more deeply imbedded in the regard and good-will of the people of Colorado than ever before in its history. Its progressive course has been watched by them with friendly and deep interest. They have been taught to know how practical and wide-reaching is the educational work that it is doing.

The students who leave the College at once put its instruction and training to practical and effective use and thus give forceful, undoubted testimony to the value of educational processes that train brain and hand to aggressive activity in the industrial world.

I can not close without speaking in terms of strong commendation of the financial management of the College under your painstaking, business-like administration. You have proved wise stewards of the high trust placed in your keeping. You have just rounded out a biennial period of college history with the institution you have so wisely fostered free from debt and in a position that gives promise of its greatly increased usefulness in the near future.

To all who have, in any way, contributed to making college administration effective and successful, I offer thanks and best wishes.

Very respectfully,

Alston Ellis

President.

Eleventh Annual Report

OF

The Agricultural Experiment Station

OF

Colorado

For the Year 1898.

Home Station,
Fort Collins, Colorado,
December 14, 1898.

The Agricultural Experiment Station,

Fort Collins, Colorado.

BOARD OF CONTROL:
The State Board of Agriculture.

EXECUTIVE COMMITTEE IN CHARGE:

A. L. KELLOGG, *Chairman*,
Rocky Ford,

ALSTON ELLIS,
Fort Collins,

JOHN J. RYAN,
Fort Collins,

P. F. SHARP,
Denver,

B. F. ROCKAFELLOW,
Canon City.

STATION COUNCIL.

Alston Ellis, A. M., Ph. D., LL. D. .... President and Director.
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C. S. Crandall, M. S. .... Horticulturist and Botanist.
W. P. Headden, A. M., Ph. D. .... Chemist.
L. G. Carpenter, M. S. .... Meteorologist and Irrigation Engineer.
C. P. Gillette, M. S. .... Entomologist.
J. E. DuBois .... Secretary.
F. H. Thompson, B. S., Stenographer.

ASSISTANTS.

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Carl H. Potter, B. S. .... Horticulturist.
Louis A. Test, B. M. E., A. C. .... Chemist.
Fred Alford, B. S. .... Chemist.
John E. Kiteley, B. S. .... Chemist.
R. E. Trimble, B. S. .... Meteorologist and Irrigation Engineer.
E. D. Ball, B. S. .... Entomologist.

SUB-STATIONS.

Harvey H. Griffin, B. S. .... Superintendent.
Arkansas Valley Experiment Station, Rocky Ford, Colorado.

J. E. Payne, M. S. .... Superintendent.
Rainbelt Experiment Station, Cheyenne Wells, Colorado.

The State Experiment Station.

SECRETARY'S FINANCIAL STATEMENT OF THE EXPERIMENT STATION FUND FOR THE FISCAL YEAR ENDING JUNE 30, 1898.

Receipts—	*United States.*	*College.*	*Total.*
United States Treasurer	$15,000.00	....	$15,000.00
Balance June 30, 1897		$1,938.89	1,938.89
Farm Products		730.69	730.69
Total	$15,000.00	$2,669.58	$17,669.58

Expenditures—	*United States.*	*College.*	*Total.*
Salaries	$ 9,601.82	$ 562.43	$10,164.25
Labor	2,223.28	265.92	2,489.20
Publications	1,206.45	285.30	1,491.75
Postage and Stationery	77.50	....	77.50
Freight and Express	24.75	....	24.75
Heat, Light, and Water	1.25	....	1.25
Chemical Supplies	....	....	....
Seeds, Plants, and Sundry Supplies	259.41	6.00	265.41
Fertilizers	104.02	2.40	106.42
Feeding Stuffs	76.53	358.65	435.18
Library	....	....	....
Tools, Implements, and Machinery	101.06	....	101.06
Furniture and Fixtures	....	....	....
Scientific Apparatus	343.41	87.66	431.07
Live-Stock	36.00	....	36.00
Traveling Expenses	806.40	467.30	1,273.70
Contingent Expenses	10.00	....	10.00
Buildings and Repairs	128.12	....	128.12
Balance	....	633.92	633.92
Total	$15,000.00	$2,669.58	$17,669.58

Letter of Transmittal.

HON. ALVA ADAMS,

Governor of Colorado.

Sir—I have the honor to present herewith the Eleventh Annual Report of the Agricultural Experiment Station which, by the terms of Congressional and State legislation, is one of the departments of THE STATE AGRICULTURAL COLLEGE of Colorado.

Both College and Station are under the direct control of The State Board of Agriculture, some of whose employes give time and effort to both College and Station work.

Two sub-stations are maintained by the use of a part of the Government fund provided for in the "Hatch Act" of 1887. Such use of said fund is unauthorized by the law, but it has been thought best "to stretch the law" a little rather than wholly to abandon the work in which the people in two important districts of the State are so deeply interested. There is faint hope yet that the Legislature, realizing how vitally concerned are our farming communities in sub-station experimentation, will furnish the financial support necessary to render it permanent and of increasing utility.

Irrigation surveys in at least two important valleys of the State and wide-reaching experiments in the growing of sugar-beets, have profitably engaged the time of some of our station workers. All scheduled lines of ex-

ried on at college expense. The salaries of employes whose service is in any way connected with both College and Station are so adjusted as financially to strengthen the latter at the expense of the former.

Our principal lines of station work, pursued without material deviation ever since that work was entered upon, are as follows: Chemistry, field experiments, meteorology, botany, horticulture, entomology, and irrigation. About two years ago, garden experiments were discontinued. I hope to see provision made for some garden work in future schedules.

There is a growing demand that our experimentation in the interest of dairying be made more far-reaching. Dairymen have just reason to ask that their interests be not overlooked in the station work paid for out of the government fund. The act creating that fund contains provisions in which experimental work closely connected with the dairy interests of the country is plainly suggested. Original researches on the physiology of animals, the diseases to which they are subject and remedies therefor, are provided for. The experimental work outlined in the "Hatch Act" includes consideration of "the composition and digestibility of the different kinds of food for domestic animals" and "the scientific and economic questions involved in the production of butter and cheese." We have not the *best* conditions for carrying out the investigations referred to in the language quoted. Our present facilities for prosecuting these investigations could be added to at no great expense; and that course is suggested by the rapidly increasing interests that would be favorably affected by its adoption. Some qualified to make suggestion assert that if the conduct of a station be put on a *business basis*, the dairy can be made efficient as an experimental agent and partially self-sustaining at the same time. The dairy interests of Colorado are now large and annually growing in importance. The alfalfa districts of the State, as they may be termed, are peculiarly fitted for the profitable handling of dairy herds. The products of such herds will

find a constantly increasing market-area when their excellent character is more widely advertised. An editorial writer in a recent issue of "The Western Creamery," published in San Francisco, expresses the opinion that "an era of great faith in dairying" is at hand. His description of some conditions favorable to the dairy industry in California might be applied with equal force to those now existing in many parts of Colorado. In referring to the superior dairy products coming from the alfalfa districts of California, he says:—

> "Until 1897 it was commonly believed that alfalfa would not make good butter, but when ten California tubs of butter were sent to the National exhibit at Owatonna and alfalfa secured the highest score of the lot, it dawned upon our people that they might be mistaken. When again, at Topeka, the alfalfa butter secured the highest score of the four tubs sent from California, an impression was made upon the trade and, with the intrinsic merit of such goods to sustain the reputation there gained, alfalfa butter has since stood in the first place in our markets."

The recent action of the Executive Committee in authorizing the feeding of a small "bunch" of yearling calves, at the sub-station at Rocky Ford, is in line with the thought that prompts me to say what I have said on dairying.

Within the last two years appropriations amounting to $1,350 have been made for the prosecution of irrigation surveys in the San Luis and Arkansas valleys. Measurements of the Arkansas river are now in progress. Prof. L. G. Carpenter, Irrigation Engineer, has direction of the work.

Experiments in the growing of sugar-beets have been made in various parts of the State. The plans for this work were perfected by Prof. W. W. Cooke, head of the Agricultural Section, and the Station Chemist, Dr. William P. Headden. All this work was but the continuation of effort begun nearly a dozen years ago. The results, as they are seen at present, may be thus summarized. Under average conditions, from 14 to 16 tons

of sugar-beets can be raised on one acre of land; their sugar content will be from 12 1/2 to 13 per cent.; and their purity will be represented by a per cent. ranging from 75 to 78.

These wide-reaching experiments have entailed upon at least two of our station workers a vast amount of labor and have been prosecuted at no slight expense to the experiment station fund. They were undertaken to show the adaptability of our soil for growing sugar-beets in amount and quality to justify capitalists in building beet-sugar factories in Colorado. The results already secured make it clear that all phases of the sugar-beet industry can be made profitable when labor and capital unite for their development. In view of what has already been accomplished—the facts now pretty definitely established—it may well be considered whether further experimental work, along the lines so well wrought out heretofore, shall be undertaken by the Station in the near future.

The work of the Entomological Section, directed by Prof. C. P. Gillette, has been, principally, an investigation of the value of different methods of destroying the codling moth, an examination of grasshopper depredations in certain localities, and a continuation of apiary investigations. The continuation of a systematic test of varieties of orchard and small fruits, has engaged a large part of the time, available for station work, of Prof. C. S. Crandall, Station Horticulturist.

We are frequently called upon for statements showing in what manner our station investigations have proved of practical benefit to the farmers of the State. Station work in Colorado has been systematically carried on ever since the "Hatch Act" made an experiment station a college department. Even before the provisions of that act were made operative, much experimental work had been intelligently planned and successfully executed. To meet with question regarding the value of the work done in the past, and that planned for the future, is to be expected. A reference to our numerous bul-

letin publications furnishes strong testimony of the far-reaching efficacy of what has been already accomplished by the well-directed efforts of our station workers.

Not long since I received a letter containing a number of inquiries regarding the *practical* results secured by our station workers in the carrying out of their investigations and researches. Some of these queries are worthy of more than a passing notice and, for that reason, are herewith given:—

1. What are the special lines of work which the Colorado station is trying to follow, and what has been the success of the work?

2. What special discoveries, if any, of scientific or practical value have been made by workers of the station?

3. Has the station discovered, or been active in introducing any system, method, process, remedy, variety, or other principle which has been of marked value?

4. Has any publication of the station been of special importance or excited special criticism?

It would require much space and no little thought to give full and satisfactory replies to such inquiries as these. They are not made by an *outsider*, but by one closely and practically identified with station work. They are suggestive of some things that the station employé should keep steadily in mind in the prosecution of his work.

Our station work, in its plan and execution, has met with the *general* approval of the authorities at Washington. In some not essential particulars that work has been criticised, perhaps justly. In so far as criticism is based upon observations made in one hasty station visit, by an official, there is ground for questioning its justness and value. Things are not the same at all times, and broad generalizations are not warranted by one hasty and, necessarily, superficial examination.

In a letter to me, under date of September 27, 1898, Dr. True, of the Government Office of Experiment Stations, writes as follows:—

"In looking over the accounts of the work of your station, during the past year, which have been received here, including the report of Dr. Allen on his visit to the station at Fort Collins and the sub-station at Rocky Ford last spring, I am impressed with the increasing value and importance of the work which your station is doing. I am particularly glad to see that not only the irrigation engineer is making successful studies of the irrigation problems, but that other officers are also beginning studies having vital relation to the successful development of farming in Colorado under irrigation. As you know, I spent some time last summer in the irrigated region west of the Mississippi and I am more than ever convinced that your station, with others, has a great opportunity for work of a high scientific and practical value by devoting itself to studies of problems directly connected with irrigation farming. There is work here for the chemist, botanist, horticulturist, agriculturist, and experts in a number of other different lines as well as for the irrigation engineer. I hope it may be possible for your station to develop this work more largely in the future and that Congress will put this Department in a position to give you financial assistance. Arrangements have already been made to utilize the investigations of your irrigation engineer in connection with the work on irrigation which the Department is attempting this year. It will be our policy to coöperate most largely with those stations which are doing the most to help themselves in this line of work."

The same official, in his annual report for the year ended June 30, 1897, speaks of our station work in the language herewith quoted:—

"The work of the Colorado station is being strengthened and developed along lines of great usefulness to a wide region of the West. The importance and value of thorough experimental inquiries in behalf of agriculture is being more fully appreciated by the managers of the station and by the agricultural public of the State. When once the station is relieved of the expensive and wasteful burden imposed by the sub-stations, it will undoubtedly be able to do still better service through coöperative and other enterprises affecting the vital interests of the agriculture of the entire State."

SOME COLLEGE BUILDINGS—NORTH FRONT, LAUREL STREET.

STATION EMPLOYES, 1898-1899.

HEREWITH ARE GIVEN THE NAMES OF ALL PERSONS REGULARLY CONNECTED WITH STATION WORK, THE POSITIONS FILLED, AND THE SALARIES RECEIVED.

Home Station— Names and Positions.	Annual Salaries from Station Fund.	
Alston Ellis, Director	$ 900.00	
W. W. Cooke, Agriculturist	500.00	
C. S. Crandall, Horticulturist	500.00	
Wm. P. Headden, Chemist	500.00	
C. P. Gillette, Entomologist	500.00	
L. G. Carpenter, Meteorologist and Irrigation Engineer	500.00	
J. E. DuBois, Secretary Executive Committee and Station Council	500.00	

ASSISTANTS.

Frank L. Watrous, Agriculture	$1,000.00	
Carl H. Potter, Horticulture	700.00	
Louis A. Test, Chemistry	900.00	
Elmer D. Ball, Entomology	900.00	
Robert E. Trimble, Meteorology	900.00	
Fred Alford, Chemistry	540.00	
John E. Kiteley, Chemistry	540.00	
Sub-Station Superintendents—		
Harvey H. Griffin, Rocky Ford	$ 900.00	
J. E. Payne, Cheyenne Wells	800.00	$11,080.00

The yearly expense for labor is about $2,500.00.

OUTLINES OF STATION WORK FOR 1898.

At a meeting of the Station Council, held January 25, the schedules of station work for the year were presented, revised, and adopted. These schedules were subsequently—January 28—adopted at a regular monthly meeting of the Executive Committee. The outlines of

experimental work for the different sections of the Home Station and for the sub-stations, located at Rocky Ford and Cheyenne Wells, are herewith given:—

AGRICULTURAL SECTION.

Spring Lambs:—

A continuation of the third year of the experiment, selling both the lambs and the ewes, closing up the experiment and making a bulletin report to be accompanied by notes on the raising of lambs on alfalfa and pasture, for which purpose twelve ewes were purchased last fall.

Ensilage:—

A continuation of the fourth year of the experiment, closing up the tests to be made with reference to sheep, cattle, and dairy cows, and making bulletin report of the whole subject as related to Colorado conditions.

Sugar Beets:—

The work in this connection to be done in coöperation with the Chemical Section, tests of seed grown in the United States as compared with that grown in Europe, tests of the effect of alkali, early and late thinning, early and late planting, medium and late irrigation, manured and unmanured land, and alfalfa sod; all these tests to be made at Fort Collins and Rocky Ford, and part of them at fourteen other places distributed in the valleys of the Platte, Arkansas, Grand, Gunnison, and on the Divide and in the San Luis Valley.

Bromus Inermis:—

Tests for hay, pasture, and seed, with and without irrigation, especially with reference to fall seeding.

Alfalfa:—

The continuation of the tests of top dressing, with duplicate tests of plowing-in stable manure; duplication of the tests of the past season on the losses of alfalfa in the stack and in the mow, and on the effect of different

times of cutting alfalfa; a test of a new variety of alfalfa as compared with the common variety, to be made at Fort Collins and Rocky Ford. and if possible, at several other places.

Corn:—

A continuation of the second year of a three years' test on the value of seed from different climates.

Winter Wheat:—

A test of its use as fall pasture for sheep, when sown after barley.

Gypsum:—

A test as a top dressing on alfalfa, as plowed in for cereals and corn, and as an addition to stable manure, in our third year of the test for the reclamation of "poverty weed" land.

Digestion Experiments:—

In connection with the Chemical Section, it is especially desired to make some digestion experiments with sheep with reference to Dr. Headden's new method for determining the feeding value of fodders by chemical analysis. The animals necessary for the experiments are already on hand. It will probably take about $75.00 to buy the necessary apparatus for performing the experiments and for fixing up the stalls to make them suitable for carrying on these lines of experimentation.

SECTION OF BOTANY AND HORTICULTURE.

I. The study of the Flora of the State, special attention being given to:

1. The weeds of the farm and garden.
2. Grasses, native and introduced.
3. The various species and varieties of the genera Oxytropis and Astragalus.

II. The further introduction to the garden of such wild fruits as can be obtained.

III. Nursery test of orchard fruits with a view to the study of the adaptability of varieties to this climate.

IV. Tests of varieties of small fruits.

V. Coöperative work with the Division of Forestry of the United States Department of Agriculture.

SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING.

I. Meteorology—To continue observations as hitherto. This includes observation and record of the data bearing on agricultural meteorology; average maximum and minimum temperatures; range; solar radiation; terrestrial radiation; rainfall and humidity observations; barometer, wind, amount, direction, etc.; and amount and intensity of sunshine. This also includes observations by various voluntary observers and at the sub-stations. To make these of most value, the stations should be visited to examine the exposure of the meteorological instruments.

II. Evaporation determinations—The continuation of that from waters, and study of evaporation from soils and vegetation.

III. Soil moisture.

*IV. Soil temperatures.

V. Continuation of examination of irrigation questions of the State—The subirrigation question of the San Luis Valley was not completed last year. The correspondence now in progress may enable its completion without taking it up as a topic for the summer. I think it is desirable to enter upon a study of the questions of the Arkansas Valley.

VI. Seepage measurements in the State—On the Arkansas and on some other streams.

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*Note—In some lines there is enough accumulation of data to make it possible to obtain useful results from their careful study. As time permits, it is intended to take up some of these questions.

ENTOMOLOGICAL SECTION.

I. Collecting and rearing insects for the purpose of determining food-habits and life-histories.

II. Experiments for the destruction of insect eggs.

III. The beginning of work looking to an Orthopterological survey of the State.

IV. Testing insecticides.

V. Experiments to determine the value of the bandage system of combatting the Codling Moth.

VI. Experiments for the destruction of miscellaneous insect pests.

VII. Experiments in the Apiary:

1. To determine the value of sugar for winter stores.
2. Testing apiary appliances.
3. Making a collection and list of honey-producing and pollen-producing plants with notes as to their probable value.
4. Experiments to determine the nature of and remedy for the disease known as "Bee Paralysis."

CHEMICAL SECTION.

I. Continuation of the soil study already begun, including a study of the effect of cropping alkali soil to sugar beets, as outlined last year.

II. Coöperation with the Farm Department in the study of the sugar beet problems in Colorado, including the subjects of the influence of the seed upon the date of maturing, effect of manuring, etc.

III. Animal digestion experiments in coöperation with the Farm Department—a continuation of the study

presented in Bulletin No. 39. This will entail an expenditure of about $75.00 by the Department of Chemistry.

Note—The miscellaneous work is not considered in this schedule. This character of work has increased very greatly during the past year.

ARKANSAS VALLEY EXPERIMENT SUB-STATION.

Rocky Ford, Colorado.

CEREALS:—

1. Wheat—A comparative test of varieties begun last season. A half acre plat each to Turkey, Clawson, Red Russian, and one-tenth acre to Canadian Velvet Chaff. One-tenth acre each of six varieties of Russian wheat furnished by the Department of Agriculture, Washington, D. C.

2. Rye—Four acres of Mammoth Spring rye; more clearly, Polish wheat.

3. Corn—(a) Test on culture. Cultivation *versus* irrigation, and how much and when best to apply each. This is the second year of a continuous test begun last season, with a slight change in the original plans, so that those portions of the field which are to receive only one or two irrigations shall not be given any water until the corn shows signs of decided need of moisture.

(b) Corn on alfalfa sod. To show how long the effects of alfalfa will last. This will be the third year of the test. The variety, Golden Beauty, will be used on a plat of four acres.

GRASSES:—

1. The establishing of test grass plats and plats of different kinds of forage crops, with tests of annual forage crops, to take the place of those drowned out the past season; the different grasses, cereals, and forage crops to be sown in single or double rows. The entire area to be limited to one-fourth of an acre.

2. Alfalfa—A test to discover if anything can be gained by planting alfalfa, in such shape as to give light

cultivation and subirrigation, where intended to produce seed; the tests to be made on an area not exceeding one-fourth of an acre.

GARDEN DIVISION.

VEGETABLES:—

A test of varieties with notes on irrigation and cultivation; to be restricted to what is needed for immediate use on the farm and for exhibition purposes.

1. Celery—To experiment with varieties and methods of growing and bleaching, on an area of two square rods.

2. Potatoes—One-half acre devoted to experiments on two varieties on the different methods of planting, culture, and irrigation.

3. Sugar Beets—One-eighth of an acre grown as a duplicate test of the experiments made at the Home Station at Fort Collins.

HORTICULTURAL DIVISION.

OLD ORCHARD:—

Observations on the amount and date of first bloom of varieties, and of the setting of fruit, and of yields. Observations of the blight and its effects on different kinds of apples and pears. The replanting of places where trees have been killed out by blight.

NEW ORCHARD:—

The vacancies in the orchard set out in 1896, caused by the dying of the trees, are to be replaced by new trees of the same varieties, but the live trees to remain in their present places. A few conifers from the Department of Agriculture, at Washington, are to be set in connection with the deciduous trees, as far as it can be done without materially increasing the labor of cultivation. The remaining 4 1-2 acres of the original ten acres set apart for the orchard, are to be set out to new varieties as far as means at hand, at this time, for this purpose, will permit.

FORESTRY AND ORNAMENTAL TREES:—

The planting of elms along one side of the lane which runs through the Station, and the planting of elm. catalpa, locust, ash, and other ornamental and nut trees around the 80 acres devoted to experimental work as far as means may be on hand for this purpose.

ENTOMOLOGICAL DIVISION.

Observations on injurious insects in connection with the Entomological Department of the Home Station. Spraying and other remedies on orchard and garden crops when affected with insects. Special observations and notes on the strawberry leaf-roller.

METEOROLOGICAL DIVISION.

A continuation of the meteorological records that have usually been kept at the Station.

FERTILIZERS.

Experiments with decomposed gypsum as a top dressing on three acres of land which received too much water last season. This land has been covered lately with manure, and the intention is to apply the gypsum at the rate of 500 pounds per acre in strips with alternate spaces left with nothing but the stable manure.

The remainder of the station land, not included in the leased land, to be used in growing such general farm crops as, in the judgment of the Superintendent, will be of most value.

RAINBELT EXPERIMENT SUB-STATION.

Cheyenne Wells, Colorado.

CAMPBELL PROCESS TEST.

I. Spring of 1898—

(a) Potatoes,........1-2 acre.
(b) Spring wheat,.....1 acre.
(c) Spring rye,........1 acre.

(d) Oats,.............1 acre.
(e) Barley,...........1 acre.
(f) Corn,............4 acres.
(g) Sorghum,.....1 1-2 acres.
Total,...........10 acres.

In each case the land is to include the part that is under the Campbell method and the check plats under ordinary cultivation; i. e., the ten acres to be about three quarters Campbell and one quarter common culture.

II. Autumn of 1898—Fall wheat, two acres selected varieties, one-half the land to be by Campbell method and the other half a check by common method.

Variety tests of grasses, cereals, and forage crops to be reduced to double rows and included in the ten acres of the Campbell test.

III. Vegetable tests to be made on a small scale and not included in the ten acres, but as far as possible made by the Campbell methods.

IV. The remainder of the farm to be devoted to forage grains, such as California barley, millet, and bromus inermis, with at least three acres devoted to a test of decomposed gypsum, at the rate of 500 and 1,000 pounds per acre.

V. Scientific work—
(a) Test effect of wind-break on soil moisture at different distances from the wind-break.
(b) Test rate of evaporation from four types of soil found here.
(c) Test evaporation from water surface in shade and sun.
(d) Continued examination of the soil of the Station which was begun in 1896.
(e) Test effect of the Campbell method on soil moisture.
(f) Observations on meteorology to be continued.

STATION PUBLICATIONS.

Within the year covered by this report, nine bulletins have been issued. The total number of bulletins is now forty-nine. A list of these publications is herewith given:—

No.	*Subjects.*	*Authors.*
1.	Reports of Experiments in Irrigation and Meteorology	Elwood Mead
2.	Report of Experiments with Grains, Grasses, and Vegetables on the College Farm	A. E. Blount
3.	Concerning the Duties of the Secretary of The State Board of Agriculture, and Distribution of Seeds	Frank J. Annis
4.	Report of Experiments with Potatoes and Tobacco	James Cassidy
5.	Experiments in the Apiary	C. M. Brose
6.	Notes on Insects and Insecticides	James Cassidy
7.	Potatoes and Sugar Beets	James Cassidy David O'Brine
8.	Alfalfa: Its Growth, Composition, and Digestibility	David O'Brine James Cassidy
9.	Soils and Alkali	David O'Brine
10.	Tobacco	David O'Brine James Cassidy
11.	Sugar Beets	C. L. Ingersoll David O'Brine
12.	Some Colorado Grasses and Their Chemical Analysis	James Cassidy David O'Brine
13.	On the Measurement and Division of Water	L. G. Carpenter
14.	Progress Bulletin on Sugar Beets	David O'Brine
15.	The Codling Moth and the Grape-Vine Leaf-Hopper	C. P. Gillette

No.	*Subjects.*	*Authors.*
16.	The Artesian Wells of Colorado and Their Relation to Irrigation	L. G. Carpenter
17.	A Preliminary Report on the Fruit Interests of the State	C. S. Crandall
18.	Index Bulletin	W. J. Quick
	Special Bulletin "A" Concerning Subjects Investigated by the Experiment Station	
19.	Observations upon Injurious Insects, Season of 1891	C. P. Gillette
20.	I. The Best Milk Tester for the Practical Use of the Farmer and Dairyman II. The Influence of Food upon the Pure Fat Present in Milk	W. J. Quick
21.	I. Sugar Beets II. Irish Potatoes III. Fruit Raising	F. L. Watrous
22.	A Preliminary Report on the Duty of Water	L. G. Carpenter
23.	Colorado Weeds	C. S. Crandall
24.	A Few Common Insect Pests	C. P. Gillette
25.	Progress Bulletin on the Loco and Larkspur	David O'Brine
26.	Garden Notes for 1893	Marion J. Huffington C. S. Crandall
	Farm Notes for 1893	W. W. Cooke Frank L. Watrous
	Seeding, Tillage, and Irrigation	Fred. Huntley
27.	The Measurement and Division of Water. (Third Edition, Revised, of Bulletin No. 13)	L. G. Carpenter
28.	The Russian Thistle	C. S. Crandall
29.	Strawberries and Grapes: Notes on Varieties	Marion J. Huffington

No.	*Subjects.*	*Authors.*
30.	I. Farm Notes for 1894	W. W. Cooke Frank L. Watrous
	II. Notes on Tomatoes	Marion J. Huffington
31.	Hemiptera of Colorado. (Technical Series, No. 1)	C. P. Gillette Carl F. Baker
32.	Sheep Feeding in Colorado	W. W. Cooke
33.	Seepage or Return Waters from Irrigation	L. G. Carpenter
34.	Cattle Feeding in Colorado	W. W. Cooke
35.	Alfalfa	Wm. P. Headden
36.	Sugar Beets	W. W. Cooke Wm. P. Headden
37.	The Birds of Colorado. (Technical Series, No. 2)	W. W. Cooke
38.	I. Sheep Scab II. A Few Insect Enemies of the Orchard	C. P. Gillette
39.	A Study of Alfalfa and Some other Hays	Wm. P. Headden
40.	Barley	W. W. Cooke
41.	Blight and Other Plant Diseases	C. S. Crandall
42.	Sugar Beets in Colorado in 1897	W. W. Cooke Wm. P. Headden
43.	I. Colorado Lepidoptera II. A Few New Species of Deltocephalus and Athysanus from Colorado III. A List of Original Types, etc., in Collection. (Technical Series, No. 3)	C. P. Gillette
44.	Further Notes on the Birds of Colorado. (Technical Series, No. 4)	W. W. Cooke
45.	The Loss of Water from Reservoirs by Seepage and Evaporation	L. G. Carpenter
46.	A Soil Study, Part I. The Crop Grown: Sugar Beets	Wm. P. Headden

47.	Colorado's Worst Insect Pests and their Remedies	C. P. Gillette
48.	Losses from Canals from Filtration or Seepage	L. G. Carpenter
49.	Meteorology of 1897, with Illustrations	L. G. Carpenter R. E. Trimble

The cost of the station publications issued since the last report is herewith given. The number of copies of each and the pages of matter therein contained are likewise shown.

I.	1,500 copies Tenth Annual Report, 110 pages, with cover		$ 119.84
II.	6,000 copies Bulletin No. 41, 22 pages		77.44
III.	7,000 copies Bulletin No. 42, 64 pages		286.39
IV.	2,000 copies bulletin No. 43, (Technical Series, No. 3,) 32 pages	$ 92.50	
	Electrotypes	2.30	94.80
V.	2,000 copies Bulletin No. 44, (Technical Series, No. 4,) 32 pages		66.00
VI.	6,000 copies Bulletin No. 45, 32 pages	$132.00	
	Electrotype	1.00	133.00
VII.	6,000 copies Bulletin No. 46, 64 pages		255.00
VIII.	6,000 copies Bulletin No. 47, 65 pages	$227.50	
	Six (6) pages half-tone work	36.00	
	Six (6) pages half-tone cuts	21.80	
	Electrotypes	15.64	300.94
IX.	6,000 copies Bulletin No. 48, 36 pages		161.25
X.	6,000 copies Bulletin No. 49, 72 pages	$252.00	
	Thirty-five (35) pages tables, $2 per page, extra	70.00	
	Two (2) pages brevier, extra	1.70	
	Electrotypes	3.30	327.00
	Total		$1,821.66

THE SUB-STATIONS.

The condition of sub-station management is that which existed at the time of the last report. The future of these auxiliaries of the Home Station is as unsettled now as it ever was. A modest state appropriation for their maintenance would insure their permanency and usefulness. As long as the burden of their support falls upon the Government fund the question of their continuance is one of anxiety and uncertainty.

In speaking of station work in Colorado, Dr. True, in his annual report, from which quotation has already been made, says:—

"The sub-stations at Cheyenne Wells and Rocky Ford have been continued, but under unsatisfactory conditions. The work at Cheyenne Wells, considered as a temporary enterprise to determine the agricultural possibilities of the locality, may prove of some value, but no good reason has been assigned for a permanent sub-station there. The sub-station at Rocky Ford has suffered the usual vicissitudes attending the prosecution of station work under ill-trained superintendents, and is clearly an expensive venture without important results."

In Dr. True's letter, before referred to, is found the following language:—

"Dr. Allen's inspection of the sub-station at Rocky Ford did not satisfy us that it had been properly managed. While there are good features about the work in progress there, there have been so many changes in the management and the records have been kept in such an incomplete and unintelligible form that it seems to us that the money spent there has been very largely wasted. I hope no effort will be spared to secure state aid to put these sub-stations on a substantial basis and permit the entire withdrawal of the Hatch fund from them. Otherwise I think definite steps should be taken to abandon them. This has been done in nearly all the states where sub-stations existed at the expense of the Hatch fund."

Dr. True's strictures upon the station work at the existing sub-stations, and his suggestions as to their fut-

ure disposition, are, in the main, warranted; but no one with only the knowledge of the conditions under which our sub-station work is conducted secured by hurried visits, few and far between, can be in a position to speak with high authority on the subjects of sub-station efficiency and sub-station continuance.

The Arkansas Valley Experiment Station—Conditions have not been favorable for securing desirable results. Three different persons have been in charge of the work of the station within a year.

W. Frank Crowley was, June 29, 1897, appointed Superintendent of the station and at once entered upon the duties of the position. His work was satisfactory and gave promise of good results. On February 10, 1898, the following communication, from Mr. Crowley, was received by the Executive Committee:—

"Honorable Sirs:—I have to-day telegraphed you my resignation as Superintendent of the Arkansas Valley Station and I further write to explain my action."

"I have resigned the position in order to establish an experimental fruit farm near Holly, Colorado. I consider that I can do more good for the horticultural interests of the Arkansas Valley by this move. I shall be glad to coöperate with the State Experiment Station in every way possible."

"The move will also, I think, better my condition financially and otherwise. I desire to move as soon as possible and shall be glad to have you put a man in this place by the first of March, or sooner. I shall endeavor to make the proposed improvements which I have begun on the station property before leaving."

"Thanking your Honorable Body for past consideration, I remain,

Yours truly,

W. FRANK CROWLEY."

The resignation was duly accepted, and an election to fill the vacancy thus created resulted in the unanimous choice of Harvey H. Griffin, at an annual salary of $900. Mr. Griffin graduated from The State Agricultural College of Colorado in 1888. From that time until now, he has been actively engaged in station work. He assumed charge of the sub-station at Rocky Ford, March 1, 1898, and at once began intelligently and vigorously

the carrying out of the season's work as scheduled prior to his appointment. His first year's work promised well, but in the very midst of the growing season came a destructive hailstorm that made havoc of many of the experiments from which such desirable outcome was confidently expected. I am confident that, under usual conditions, the future work of the station will meet the reasonable expectations of the public.

A part of the land belonging to the station has been leased, as the total acreage was not needed for the proper carrying on of the scheduled station work. At a meeting of the Executive Committee, held August 30, 1898, Chairman Kellogg was authorized to re-lease the land, unused by the station, to Francis Harson.

For the year, closed June 30, 1898, the expenditures were as follows:—

Superintendent's salary	$833.33	
Labor	976.96	
Other expenses	387.28	
Total		$2,197.57

Farm sales, for the same year, amounted to $519.69.

Divide Station—This station has not been operated as an experimental farm since March 31, 1896, since which time it has been leased to W. A. Diebold, of Table Rock, who has proved a prompt-paying tenant. The station land, forty acres, is rented for $40 per annum, the tenant making repairs and improvements at his own charge. The station house is in bad condition but the barn and sheds are in good repair. The cottonwood trees have maintained their reputation for hardiness but the apple and cherry trees have died. A seventeen-acre tract of land, sown to wheat April 8-11, yielded 18 bushels to the acre. A six-acre barley field gave a yield of over 11 bushels per acre, from seed sown May 24. The potato crop, from a four-acre field planted May 18-23, proved of little worth, the yield not exceeding 1,000 pounds per acre.

SOME COLLEGE BUILDINGS—EAST FRONT, COLLEGE AVENUE

The San Luis Valley Sub-Station—The station land, 180 acres, had been leased to J. H. Stone who has furnished some statements of crop production. Thirty-eight acres, of the east 80-acre tract, produced 1,405 bushels of oats of good quality. The rest of said tract gave two tons of field peas per acre. Nine acres of alfalfa land produced 18 tons of hay. The west 80-acre tract, sown to wheat, gave a yield of 30 bushels per acre.

Rent receipts from this sub-station amount to $161; the year's expense—water rent—is reported to be $25.

The Delta County Sub-Station—A sub-station in Delta county was authorized by act of the Legislature approved April 4, 1887. No steps looking to the establishment of a station were taken until about two years ago when a 40-acre tract of land, eligibly located and well adapted to fruit culture, was donated to the college authorities, having ultimate control of station work, by Delta county. Then effort was made, without avail, to secure a legislative appropriation to enable the Governing Board to open the station for the prosecution of that experimental work of greatest value to the people of the Western Slope.

The following action relating to the land donated by Delta county for the establishment of an experiment station was taken by the Executive Committee at its April meeting, 1898:—

"Whereas, The State Legislature has entirely failed to aid The State Board of Agriculture in the maintenance of experiment stations located in different parts of the State; and

"Whereas, It is in direct violation of the spirit of the law, as construed by the Department at Washington, for any portion of the money derived from the so-called *Hatch Act* to be expended upon outlying sub-stations; therefore,

"Resolved, That the Secretary be instructed to notify the County Commissioners of Delta county that, for reasons above given, The State Board of Agriculture is unable to comply with the (at least implied) contract to keep up an experiment station in Delta county and that it is the sense of the Executive Committee of The State Board of Agriculture that all holdings of said

Board, derived from said Delta county for the purpose of establishing an experiment station, be deeded back to the proper authorities of said county, if their wish is to receive the property."

At the semi-annual meeting of The State Board of Agriculture, held June 1, 1898, the following action was taken:—

"Resolved, That the President and Secretary of The State Board of Agriculture be and they are hereby authorized to execute a deed to the County Commissioners of Delta county, Colorado, for the south-east quarter of the south-west quarter of section thirty-five, township fourteen, south of range ninety-five west of the sixth principal meridian, being the forty acres of land deeded by said county to The State Board of Agriculture for an experiment station, together with a transfer of the water stock thereto belonging."

The deed authorized in the resolution has been drawn, properly acknowledged, and forwarded to Delta county. Thus eleven years of ineffectual effort to make provision for experimental work in fruit growing in Western Colorado have come to a close.

The Rainbelt Sub-Station—This station, established at Cheyenne Wells nearly five years ago, has had an uneventful history. The advisability of opening a station in the "arid region" is a question about which "much might be said on both sides." The so-called rainbelt district of Colorado is of considerable extent and contains soil of acknowledged fertility. Stockmen have used the most accessible and promising portions of it as grazing fields for their herds but, until recently, no efforts worthy of consideration have been made to test the adaptability of the plains of Eastern Colorado for the homes of an agricultural people. The prime object of the work in Cheyenne county is to settle, as far as intelligent, scientific investigation can give answer, the questions of most importance to the people of a semi-arid region. If any considerable portion of lands now regarded as well-nigh valueless can be shown to be fit

for the homes of an industrious, frugal people, a result worth the cost of station maintenance for many years will be reached.

After the gubernatorial veto, two years ago, of a bill making provision for the support of this station by money taken from the general revenue for college support, the following action was taken by The State Board of Agriculture, at a special meeting held April 20, 1897:—

"Ordered, by The State Board of Agriculture of Colorado, That the sum of two thousand five hundred dollars ($2,500) be and is hereby appropriated out of any available college revenue for the support and maintenance of the agricultural experiment station located at Cheyenne Wells, Colorado; said appropriation being for a period of two years."

"The purpose of this action is to set at rest, definitely, the statements that have been made by certain parties that the Board contemplated the abandonment of said station at Cheyenne Wells, or would, in the case of its continuance, fail to give it such financial support as would secure the best results from it."

"The Executive Committee is hereby directed to make such drafts upon the appropriation herein specifically set apart for the support of said station as in its judgment may be necessary for the full realization of the purport and intent of the order above given."

There is yet a balance of appropriation, in the station treasury, for the support of this sub-station, amounting to $481.38. With this sum must be met all expenses connected with the sub-station maintenance up to March 1, 1899.

The station expense for the fiscal year, ended June 30, 1898, may be summarized as follows:—

Superintendent's salary	$800.00	
Labor	146.40	
Equipment and incidentals	437.56	
Total		$1,383.96

The sale receipts are insignificant, being only $10.

At a recent meeting of your Committee, Messrs. P. F. Sharp and B. F. Rockafellow, a sub-committee, who had visited the sub-station at Cheyenne Wells, and investigated its workings and possibilities, made report as follows:—

"The location being on the Great Plains, about 175 miles east from Colorado Springs, where the buffalo and grama grasses are abundant, owing to the lack of water and all growth except native grasses, indicating its being heretofore the summer range of the buffalo and the possibility of its being made the limitless range for domestic animals and, if certain conditions are complied with, the homes of a large population engaged chiefly in such pursuits as permanent as agriculture or mining, we deemed it our duty to cast about to see if our experimental work is on the lines of providing a possible success."

"It has been shown to our minds that if the Government and the possessor of the land-grant, the joint owners of the country, can join, with the railroad as a base line, in sinking bore-hole wells on the line between belts of stock range extending back for miles, that water, without which the country can not be made habitable the year round, can be secured, as is done here, at a depth of 300 feet and in sufficient quantities for domestic and stock purposes—then, as proving what kind of development is possible to make the home of the future possessors of this vast region habitable, we consider the location of this experiment station wisely chosen."

"We found, by low-trained living apple and cherry trees, five years set and of healthy though slow growth through monthly stirring of the surface by the cultivator, by a moderate growth of alfalfa yielding the second year about one ton per acre, Bromus inermis or Russian grass, sorghum, corn, peas, broom corn, Kaffir corn, large sweet-potatoes, small but exceedingly rich Irish potatoes and melons, and gooseberry bushes in bearing, that there is sufficient moisture to promote slow growth and small yield where the conditions are made and kept as favorable as possible. Thus, it is possible, in this otherwise treeless belt, to make living possible, less monotonous, and more enjoyable."

"The station having been established only a few years, and consequently its work but fairly commenced, we believe in its continuance and recommend certain expenditures now necessary."

"We deem the location of the station, partly at the foot of slopes and thus taking the wash from the higher lands in time

of storms, as demonstrating the advantage of such locations where any sort of cultivation is aimed at."

"The soil of this region being rich, experiments have been made with grasses from Asiatic and other arid countries with the hope to find some forage plant that will produce larger yields than our native grasses, without success so far, except on the short-time test of Russian grass of which a good stand has been secured. This grass will be anxiously watched to note the outlook after the winter has passed. As this forage plant has a large blue-grass blade and has so soon shown its kindly adaptation to this climate, we are hopeful that the cost of this station to the Government has, in its growth, already been returned manifold, but if not, some other plant filling the requirements will yet be found by the pe'sistent, able efforts of our painstaking Superintendent, J. E. Payne, whose studious, industrious, and faithful service we most earnestly commend."

"Successful experiments in the use of gypsum as a moisture retainer, as well as a stimulating fertilizer for making the properties of the soil active, have been made, showing in one instance 60% advantage."

"The machinery and appliances for testing the *Campbell Theory* are on the ground and their use, part of the season, has proved very satisfactory. They will be given thorough use the coming season."

CONCLUSION.

Our station workers, particularly those of the Home Station, have rendered much and acceptable service as lecturers before farmers' institutes, horticultural conventions, and other bodies whose aims and purposes intersect the industrial life of the people.

The station work prosecuted outside of Larimer county, in which the Home Station is located, has cost the experiment station fund not less than $6,000 within the year. The station publications, sent into nearly every post-office district of the State as well as to other states and foreign countries, made drafts, upon the same fund, amounting to a sum but little less than $2,000. All station work is designed to promote the agricultural interests of the whole State, whether it is done at the Home Station, the sub-stations, or elsewhere.

Herewith are presented the reports of members of the Station Council, in the order in which they reached my office; also the reports of Superintendents of the substations.

An early planning of station effort to be put forth the coming year is recommended.

Respectfully submitted,

ALSTON ELLIS,

Director.

Fort Collins, Colorado, December 14, 1898.

Report of the Section of Botany and Horticulture.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—I have the honor to submit the following report on the work of the Section of Botany and Horticulture for the year 1898.

In 1894 the Department commenced a systematic test of varieties of orchard and small fruits. The horticultural work of this season has been mainly a continuation of this test. Some additions to the lists of varieties previously reported have been made. Much of the effort of the Department has been required in the care of trees and plants set in previous years, and in the maintenance of records that, when compiled on the completion of the test, may show the complete history of each particular variety.

In the spring of 1896 a new apple orchard was planted with trees from the station nursery. The area planted was about five acres, requiring 480 trees which represented 140 varieties. The land lies high, the soil is good, and the subsoil of such nature that water is not retained, but quickly seeps to the lower land adjoining. It is dependent for water upon the No. 2 ditch, and for the three seasons since the first planting the supply has been wholly inadequate for the successful starting of young trees.

The record for 1896 shows that planting began as soon as water was available, April 24, but the next day

the water was turned out of the ditch and the remaining trees were watered, in part from a hydrant and in part by water hauled in barrels. The further record of irrigation for the season is as follows. May 1 and 2 a small stream was obtained and run on about half the orchard; May 13 to 15 a run was secured, and again June 22 to 25. No water was available during the balance of the season. Under these conditions the summer loss was considerable, and the living trees entered the winter in very poor condition. The winter of 1896-'97 was a very open one; much of the time there was no frost in the ground and evaporation was continuous, proving destructive to the trees. The planting in 1897 was practically a resetting of the whole orchard, the number of trees required to fill vacancies being 315. Two additional rows were added, making the total number of trees planted 344. The planting was done May 6 to 8 and water was at hand until the work was completed. From this time until the 14th of June no water was available; then we had it for two days, and again June 28 and 29, and this was the last obtainable during the season. The loss during the summer and winter of 1897-'98 amounted to 115 trees or about 22%, being nearly evenly distributed between the trees planted in 1896 and those planted in 1897. Vacancies were again filled this last spring, the work of planting being commenced on May 9 (as soon as the ground was in fit condition after the storm of April 30 to May 5, during which 3 inches of rain fell) and was finished on May 11. Between planting and the end of the season, water was available for but two days, May 23 and 24. On October 12 water again came in the ditch and continued for five days. During this time it was run on the orchard night and day, and the ground thoroughly soaked.

A count of the orchard made last month shows 46 existing vacancies, 33 of these are among trees set last spring, 9 among trees set in 1897, and 4 among trees planted in 1896. It is proposed again to fill these places next spring. As the orchard now stands it contains 461

trees representing 145 varieties, but many of these trees show very low vitality and have made very little growth.

In any assemblage of a large number of varieties it is to be expected that some, perhaps a considerable portion, will prove failures, but under the conditions as above outlined the trial of these varieties can hardly be regarded as fair, and we are not warranted in condemning them. During the past season we have made a special effort in the direction of cultivation, keeping the surface soil continually loose. This has undoubtedly aided in preventing evaporation, but it did not supply the deficiency which was apparent in the appearance of the trees.

The experience of the three seasons has forced the conviction that unless an adequate water supply can, in some way be secured, further attempt to establish the orchard will be effort thrown away. I have, therefore, presented the facts in some detail and would respectfully ask your consideration of the matter.

The plum orchard is under the same conditions regarding water supply as the apple orchard, but the trees have in the main made a reasonable growth, and such losses as have occurred are among varieties that have proved too tender to withstand the cold of winter. The effect of short water supply has, however, been apparent among the varieties now fruiting. It was most noticeable in 1897 when the crop borne was heavy, but even this season when the trees bore only a light crop, the fruit was below normal in size.

This orchard as now platted has places for 601 trees. There are 58 vacancies, to be filled next spring, and 543 living trees representing 153 varieties. These varieties are distributed among the different classes of plums as follows—

Prunus Americana	71
Wild Goose group	24
Prunus domestica	30
Japanese group	17

Chicasaw group	6
Beach plum	1
Hybrids, unclassified	4

It is evident from our work thus far with plums that the native American varieties are the ones to be relied upon for this region. A few of the Wild Goose group like Miner and Prairie Flower are hardy and do well, and it is probable that a few of the domestica plums, and possibly some of the Japanese varieties may after further trial prove valuable additions, but the greater number of these last mentioned groups and all of the Chicasaw group, so far as we have tried them, are practically worthless for this part of the State, because they do not survive the winters.

Last spring, studies on the blossoming periods, on self-fertility, and on crossing were outlined and carried out. The results are of some value although seriously interfered with by the cold storm which prevailed from April 30 to May 5. Early varieties began opening flowers on April 27 and many varieties were sufficiently advanced to be badly injured by the prolonged cold, and the snow which held to the branches for several days. Domestica varieties received the greatest injury; on some the fruit buds being all killed, even though still dormant. All varieties were in some degree injured and the light crop can be directly attributed to this cause. The work with plums has been made the subject of a bulletin which is now ready to be submitted.

The test of varieties of strawberries and bush fruits has been carried on as in years previous, and the records accumulated are sufficient to warrant a report on the varieties under trial. This matter is now being arranged for publication.

The coöperative experiment with the division of Forestry of the U. S. Department of Agriculture to test the relative hardiness of forest-tree seedlings as grown from seeds produced in different sections of the country has been continued this season. As started in

1897 there were provided 88 packages of seeds representing 11 species from 22 states and Canada. The addition made last spring consisted of 52 packages representing 9 species from 14 states. The range of climate now represented is sufficiently extended to make the test an interesting one. Under instructions from the Forestry Division the seedlings of 1897 were transplanted in May to allow them room for development. The records thus far made, while not regarded as conclusive, show some interesting results that point strongly to the conclusion that in the matter of hardiness the seedlings from northern seed have a decided advantage over those from southern seed. It is the expressed intention of the Forestry Division to continue this experiment until the results justify a positive conclusion.

The addition of five acres to the forestry plantation planned for last spring was deferred owing, as I am advised, to lack of funds. For the same reason the help necessary to keep the plats free from weeds, and in good growing condition could not be employed. No work has been done since July, and the plats have presented an untidy appearance. There being no water available for irrigating, the growth made during the season was small. Under these circumstances the advancement of the plantation has been unsatisfactory and much less encouraging than for the year 1897. The seedlings received last spring were as follows: Maple 5,000, Austrian pine 12,000, Scotch pine 12,000, Bull pine 9,000. Most of these were used to plant between the other trees and to fill vacancies; the balance being planted in nursery rows. Thus far the attempt to grow pines and spruces has been a practical failure, but it is hoped that when the nurse trees attain greater size, affording protection from the sun, these trees will succeed better. I have as yet received no information as to the work contemplated for next year.

In pursuance of the work on a flora of the State and for the purpose of adding to our collection of plants for exchange, several short trips were made during the sea-

son. In May one week was spent in an examination of the spring flora of the Western Slope; collections being made at Palisades, Grand Junction, and Cimarron. During the latter part of June and early July two weeks were spent in the southern portion of the state, and collections made at Antonito, Durango, Silverton, Mancos, and Rico. This was followed late in July by a wagon trip into the mountains west of Fort Collins, and in August one day was spent on Gray's Peak. At all places visited, and when traveling between points, lists of plants seen were made, thus adding largely to our records regarding the distribution of native and introduced plants.

Particular attention was given to the grasses and forage plants found at each place visited, and lists of weeds were also made.

The number of species now available in quantity for exchange exceeds 700 and it is hoped that the herbarium can be largely increased through exchanges to be made. The importance of a larger and more representative collection of North American plants is each year becoming more apparent. The greater the number of species in the collection, the more will it facilitate the work of determining the plants sent to us, and this feature of the department work is increasing each year. Since January first we have named 448 plants which have come to us from various parts of the State, and one collection of about 100 species is waiting attention as soon as time can be spared from other work. Many of the plants sent here are acceptable additions to the herbarium, and coming as they often do from regions not yet visited by the writer they add to our records of distribution.

The number of specimens added to the herbarium by exchange during the year is about 2,000. Several offers of exchange for the coming year have been made, some of which it is hoped we may be able to accept, but the available time for work of this character is so limited that but few exchanges can be undertaken.

The Department has prepared one bulletin during the year, No. 41, "Blight and Other Plant Diseases." The blight of apple and pear trees has, in its spread westward, reached the orchards of Delta and Mesa counties and many inquiries regarding it have been received during the summer.

Colorado orchards have in past years been free from fungus diseases, but the diseases which have given the eastern growers trouble are gradually coming in, and there is a rapidly growing interest in them among the fruit growers. Besides the blight, which is caused by a bacterium, several parasitic fungi have been sent to us from different parts of the State with reports of more or less serious injury. Four of these had been previously reported from other counties; three had not before been reported in the State. The Leaf Spot of blackberries and raspberries (*Septoria rubi*) has come from three counties and is said to be doing much damage. The Orange Rust of blackberries (*Cæoma nitens*) and the Leaf Blight of the strawberry (*Sphærella fragariæ*) are reported from several localities. The Powdery Mildew of the cherry (*Podosphæra oxyacanthæ*) is reported from the Arkansas valley, and from the same region four growers of cantaloupes have sent a blight disease which is said to be doing much injury, and which proves to be caused by a species recently described by Messrs. Ellis and Everhart as *Macrosporium cucumerinum*. The Anthracnose of the raspberry, and the Apple Scab are also reported, but have as yet done no very serious injury. These fungus diseases are sure to become very important factors in the business of fruit growing, and as the applications for information increase it will be necessary to make the investigation of these diseases and their remedies a more important feature of the department work.

Respectfully submitted,

C. S. CRANDALL,
Botanist and Horticulturist.

Fort Collins, Colorado, December 14, 1898.

Report of the Agricultural Section.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—I have the honor to submit the following report of the work of the Agricultural Section for the year 1898.

The larger part of the time and energies of the Section has been devoted to the investigation of the growth of sugar-beets in Colorado. In connection with the Denver Chamber of Commerce the work has been extended to include all those parts of the State that seem at all adapted to this crop. A large part of the seed was obtained from the United States Department of Agriculture, but some from the Oxnard Sugar Company of Grand Island, Nebraska, through the efforts of the officials of the Union Pacific, Denver and Gulf Railroad, and some from the sugar factory at Rome, N. Y., through the efforts of Mr. M. B. Colt, of Alamosa. When near the end of the season all these sources had become exhausted, the Denver Chamber of Commerce purchased in open market enough seed to supply the remainder of the demands. In all a little over four thousand pounds of seed were distributed to two thousand three hundred persons.

The Denver Chamber of Commerce in connection with the County Commissioners, or the local organizations, offered prizes aggregating nearly two thousand dollars to those who raised the best crops of sugar-beets. These competitions were confined to the irrigated

parts of the State. Seed was distributed, however, to many persons outside of the counties where the prizes were offered. About forty persons agreed to carry on some special tests for this Section, and extended tests were conducted on the sub-station at Rocky Ford and on the college farm. Thus the work of the season has been carried out in four distinct lines.

1. General tests were made on the growth of beets in the unirrigated parts of the State and in some of the counties having irrigation but not enough interest in the matter to offer prizes for large crops. From this source were received ninety-one samples of beets, most of them accompanied by full notes on the planting and cultivation of the crops and by less satisfactory notes on the harvesting and yield.

2. Records were received from nine counties in competition for the prizes. It was recognized last spring that the time had come when there should be a well organized effort to get the most exact information possible on the adaptation of the sugar-beet to Colorado soil and climate. Nearly all the estimates of previous beet crops in Colorado have been based on the yield from a hundred square feet of ground. It was recognized by all that this was too small a plat for commercial estimates. It had been adopted because the beet growers disliked to spend the large amount of time and trouble necessary to make exact experiments on a large scale. It was seen that some substantial inducement must be offered before it could be expected that better results would be obtained than those of former years. It was with this idea in view that the prizes were offered and the results have confirmed the judgment and justified the large expenditure of time, labor, and money. Seventy-two persons competed for the prizes and their records form such a valuable mass of material that they are included in this report.

3. The work of testing foreign grown seed as compared with that grown in the United States was undertaken. Two of the best German varieties, one of the

EXPERIMENT STATION—FIELD CORN, SUGAR BEETS IN FOREGROUND

French, and one of the Austrian were compared with one lot of seed grown in Utah and one grown in New Mexico. These were distributed to about forty persons in all the principal agricultural sections of the State and some of the most interesting and valuable results have been obtained. The superiority of the Utah grown seed was very marked over the seed from which it originated, so much so that arrangements have been made to grow seed next year on the college farm and at various places throughout the State from some of the beets that made exceptionally good returns the past season.

4. The work at Rocky Ford and the college farm was principally along the lines of different times of planting, distances of thinning, times of thinning, and date of irrigation. About two hundred samples of beets were analyzed from these two sources but the results have not yet been carefully enough studied to know what they indicate.

In connection with the shipment of eight carloads of beets from Loveland and Fort Collins to Grand Island, Nebraska, many samples were taken to ascertain tare in trimming, shrinkage in shipping, and yields from large areas under ordinary farm management.

It will thus be seen that the work has been conducted on a larger scale than ever before attempted. Some idea of the labor involved can be gotten from the fact that my letterbook shows one thousand six hundred and sixty-six letters written during the first eleven months of this year in addition to several thousand mimeograph circulars. To do this in addition to my other work would have been an impossibility and extra clerical assistance was granted through the five summer months.

The records sent in competition for the prizes present the largest amount of the most reliable reports that have ever been collected concerning Colorado sugar-beets. They made such a remarkable showing for the State that they are included in this report. They are based on the yields of one-sixteenth of an acre.

from the crops in an ordinary factory. It is considered that this measures the true sugar value of the crop and it is on the figures of this column that the order of excellence of the various crops is based.

In the table of averages by counties another column is introduced headed "Factory value per acre." This is intended to represent the amount that would be paid for the crop at a factory under present prices. It is obtained by deducting 10 per cent. tare from the gross weight of the crop and multiplying the remainder by the price paid by factories during 1898, where the price is varied according to the quality of the beets. The prices used are: Three dollars and seventy-five cents per ton for beets testing from 12.00 per cent. to 14.40 per cent. sugar and of less than 78 per cent. purity; $4 per ton for the same per cent. of sugar and more than 78 per cent. purity; $4.25 per ton for tests from 14.50 to 15.40 per cent. sugar; $4.50 per ton for tests from 15.50 to 16.40 per cent. sugar; $4.75 per ton for tests of 16.50 or higher per cent. sugar.

SUGAR-BEET CULTURE.

CONEJOS COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
Charles Milne, La Jara	Nov. 7	28.16	17 65	79.8	7,952	6,436
W. M. Martin, Alamosa	Oct. 29	24.57	16.96	86.8	6,684	5,802
W. A. Braiden, La Jara	Oct. 10	20.05	11.45	72.2	3,673	2,803
G. W. Shaw, Alamosa	Oct. 22	12.29	15.30	86.6	3,008	2,605
D. E. Newcomb, La Jara	Oct. 12	12.80	15.65	80.1	3,205	2,563
S. J. Parish, Alamosa	Oct. 16	12.06	16 64	80.5	3 174	2,554
W. G. Bradshaw, Alamosa	Oct. 21	12.40	15.77	80.0	3,129	2,499
A. McKinnon, Alamosa	Oct. 18	7.26	12.54	83.8	1,457	1,213
Peter Legard, Alamosa	Oct. 20	....	15.58	....	....	....
Average	Oct. 21	16 20	15.26	81 2	3,955	3,221

SUGAR-BEET CULTURE—Continued.

GARFIELD COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
C. H. Harris, Catherin	Oct. 29	37.98	17.20	80.1	10,458	8,397
D. G. Edgerton, Carbondale	Oct. 18	14.91	17.34	91.8	4,113	3,776
Jesse Kerlee, Parachute	Oct. 19	10.77	15.68	88 0	2,702	2,378
Charles H. Miller, Antlers	Oct 17	12.17	14.25	79 4	2,774	2,203
Average	Oct. 21	18 96	16.12	84 8	4,901	4,155

SUGAR-BEET CULTURE—Continued.

LARIMER COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
J. M. Naylor, Loveland	Oct. 23	36.20	16.53	79.3	9,590	7,589
I. W. Clapper, Loveland	Nov. 1	31.60	18.53	80.4	9,369	7,533
C. C. Smith, Loveland	Oct. 27	33.01	14.73	79.0	7,781	6,147
F. G. Bartholf, Loveland	Oct. 31	28,72	15.68	85.3	7,205	6,142
Alfred Wild, Loveland	Oct. 27	31.50	15.25	80.7	7,606	6,138
Alvin Shields, Loveland	Oct. 29	27.47	17.43	79.7	7,490	5.970
Harvey Skinner, Loveland	Oct. 27	24.80	17.38	85.3	6,896	5,882
R. O. Joslyn, Loveland	Oct. 27	14.10	18.05	84.8	4,072	3.453
R. S. Cox, Loveland	Oct. 27	21.05	13.40	75.7	4,513	3,416
P. C. Benson, Loveland	Oct. 31	10.72	19.05	86.0	3,267	2,810
N. R. Faulkner, Loveland	Oct. 22	19.35	12.07	74.0	3,456	2,765
Average	Oct. 28	25.32	15.69	80.9	6,356	5,091

SUGAR-BEET CULTURE—Continued.

LOGAN COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
Fred Bernhard, Sterling	Sept. 26	34.15	13.40	72 7	7,322	5,323
W. C. Propst, Merino*	Sept. 25	24.50	14.72	76 2	5,771	4,397
A. F. Krause, Sterling*	Sept. 27	21.50	14.50	84.7	4,988	4,175
J. H. King, Sterling	Sept. 27	18.10	13.30	79.1	3,852	3,047
C. D. Brownell, Iliff	Sept. 26	14 60	14.72	80 0	3,438	2,750
C. M. C. Woolman, Sterling*	Sept. 27	12.50	14.30	72 4	2,860	2,071
C. E. Harter, Sterling	Sept. 27	9 50	15.33	78.8	2,331	1,837
T. A. Whiteley, Sterling	Sept. 26	7.65	14.15	71 6	1,730	1,239
James Weir, Sterling	Sept. 26		14.49	78.2		
M. V. Propst, Sterling	Sept. 26		14 25	78 8		
John Landrum, Sterling	Oct. 1		14 10	79.2		
R. C. Perkins, Sterling	Sept. 27		13.30	79.1		
H. C. Hatch, Sterling	Sept. 26		12.63	73.3		
Average	Sept 27	17 8	14.09	77.3	4,013	3,102

*The crop from 100 square feet of ground is used in making these estimates of yield per acre. The rest of the yields are based on one-sixteenth of an acre.

SUGAR-BEET CULTURE—Continued.

OTERO COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
J. W. Ruble, Rocky Ford	Oct. 25	31.40	18.19	86.2	9,138	7,877
J. P. Pollock, La Junta	Nov. 7	33.52	18.01	77.7	9,652	7,520
B. F. Wyckoff, Rocky Ford	Oct. 25	23.21	14.16	78.3	5,259	4,108
Albert Conner, Rocky Ford	Oct. 27	27.70	10.83	72.8	4,800	3,494
C. S. McKinley, Fowler	Oct. 20	13.27	16.06	84.7	3,411	2,889
Fred Janrow, Fowler	Oct. 29	18.17	13.30	73.6	3,906	2,875
Richard Mason, Higbee	Oct. 20	10.70	15.20	78.3	2,603	2,048
C. S Heath, La Junta	Oct. 26		15.39	76.8		
Average	Oct. 26	22.59	15.14	79.8	5,474	4,379

SUGAR-BEET CULTURE—Continued.

WELD COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
Leonard Burch, New Windsor	Oct. 25	17.17	17.10	83.5	4 699	3,924
Newton Clegg, Greeley	Oct. 25	12.20	16.25	78.1	3,172	2,477
Martin Nelson, Greeley	Oct. 18	12 58	15.68	74.2	3,154	2,340
Fritz Niemeyer, Evans	Oct. 26	....	14 54	82 4	....	....
Average	Oct. 23	13.98	15.89	79.8	3,562	2,850

SUGAR-BEET CULTURE—Concluded.

AVERAGE RESULTS BY COUNTIES.

County	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds	Factory Value Per Acre
Conejos	Oct. 21	16.20	15 26	81 2	3,955	3,221	$ 62 02
Delta	Oct. 23	22.54	14.74	80.0	5,301	4,241	86 23
Fremont	Oct. 23	23.36	16 87	84.1	6,226	5,236	99 75
Garfield	Oct. 21	18.96	16.12	84 8	4,901	4,155	76 98
Larimer	Oct. 28	25.32	15.52	80.2	6,278	5,023	102 56
Logan	Sept 27	17.80	14 09	77.3	4,013	3,102	64 00
Otero	Sept. 26	22.59	15 14	79 8	5,474	4,374	86 40
Weld	Sept. 23	13.98	15 89	79.8	3,562	2,850	56 70
Grand average	Oct. 20	20 05	15 43	80 8	4,955	3,995	$ 76 67

In considering the foregoing tables one is struck at once with the high average excellence of the sugar-beets of Colorado as regards both quantity and quality. In the districts of the United States where beets are raised for factories, 12 per cent. of sugar and 78 per cent. purity are considered standards and that one who has raised ten to thirteen tons of beets per acre has done well. A fair estimate of the cost of raising sugar beets is $30 per acre, while the above table gives $76.67 as the average factory value for the whole state. The difference of $46.67 profit per acre will compare well with any other kind of farming practiced in Colorado, not even excepting the famed cantaloupes of the Arkansas valley, the orchards of the Western slope, or the lambs of the northern feeding districts.

Among the other subjects considered by this Section, during the year, may be mentioned the feeding of sheep and lambs on alfalfa. An experiment along this line was conducted on the college farm and data were secured on the subject from nearly every person in the Arkansas Valley that had tested this method of feeding. The results will be ready for issuing as a bulletin early this winter.

We completed our tests of raising early lambs and the final report will be made in connection with the above bulletin.

The second year's test of our three years' test of corn grown from seed from different altitudes and latitudes was somewhat injured by the early frost the first week in September, but it served to emphasize the differences of the plats in their time of ripening.

We are now engaged in our final tests of feeding ensilage and sugar-beets to cows and sheep.

The bulletins issued by this Section during the year have been one, in connection with the Chemical Section, on "Sugar Beets in Colorado in 1897" and a technical bulletin entitled "Further Notes on Colorado Birds." The collection of data on the above subject was kept in

mind during the past season in connection with the trips made over the State on the sugar-beet work and almost as many additional notes collected as were given in the above-mentioned bulletin.

Respectfully submitted,

W. W. COOKE,
Agriculturist.

Fort Collins, Colorado, November 30, 1898.

Report of the Entomological Section.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—I have the honor to submit herewith the annual report of the Entomological Section of the Agricultural Experiment Station for the year 1898.

While this is hardly the place for a detailed account of experimental work, I presume it will not be out of place for me to call attention to the more important results that have been reached.

EXPERIMENTS WITH THE CODLING MOTH (*Carpocapsa pomonella*).

The experiments with this insect were chiefly for the purpose of determining the comparative values of different methods of combatting the pest, to determine the number of broods in the vicinity of Fort Collins, and to compare the results of early with late spraying.

The three remedies compared were, gathering the fallen apples daily to destroy them, catching the larvae under bandages put around the trunks of the trees, and spraying twice with Paris green. To test the first remedy, the fallen apples were gathered each morning and examined for worms throughout the season. In this manner 16% of all worms infesting the fruit of Duchess trees and $3\frac{1}{2}$% of the worms infesting the fruit of Ben Davis trees were taken. By the bandage system 17% of the worms were taken on all trees up to the time of gathering the fruit.

By twice spraying with Paris green and estimating the benefits by the effect upon the first brood only, it was found that 83% were destroyed upon Ben Davis trees. The Ben Davis trees were sprayed when the calyx cups were still wide open. This work was compared with the result on a Duchess tree where the calyx cups had closed before the first spraying. The saving in the latter case was only 25.4%.

The experiments also show quite conclusively that there are but two broods of the codling moth a year in northern Colorado.

ORTHOPTEROLOGICAL SURVEY.

Good progress has been made in a study of the Orthoptera (grasshoppers, locusts, crickets, etc.) of the State. Quite extensive collecting has been done in the vicinity of Fort Collins, both inside and outside the foothills. Mr. Ball spent two weeks in the southeastern portion of the State collecting and studying these insects, and the writer made one trip to Delta and Grand Junction and another to Marshall Pass, Salida, Palmer Lake, and Boulder for the same purpose. Not less than two thousand specimens have been added to the station collection during this work and the number of Colorado species in the collection has been very largely increased. It will probably require two or three summers yet to bring this work to a fair stage of completion.

In the fruit-growing districts on the west side of the Range I found the differential locust (*Melonoplus differentialis*) the chief depredator this summer, though the two-lined locust (*Melonoplus bivittatus*), the red-legged locust (*Melonoplus femur-rubrum*), and a green locust (*Schistocerca emarginata*) were doing decided injury in many places. On this side of the Range the two-lined locust has been by far the most injurious species. Next in importance has been the red-legged locust. These two species are the only ones that we have found doing very serious harm to cultivated crops on this side of the foothills.

EXPERIMENTS WITH SHEEP SCAB.

Possibly the most important result reached in studying this disease the past year has been the determination of the life history of the mite. Seventy-five eggs were taken from the back of an infested sheep and put, in about equal numbers, upon the skin of the backs of two lambs that were free from the disease. The mites began hatching the 1st day and continued until the end of the 4th day; on the 9th day the earliest hatched individuals were mature and were seen in copula; and on the 11th day eggs began to be deposited. This would indicate that, to cure scab, the second dipping should not be sooner than five days after the first nor should it be postponed longer than ten days. Otherwise there will probably be some eggs upon the sheep, unhatched when the second dipping is made.

The experiment also shows the time required for the full round of development from egg to egg again is fourteen or fifteen days, as the oldest mites in the experiment came from eggs that were ready to hatch when first transferred and hence must have been about four days old when the observations began. The transfer of the eggs was made by the writer and the observations upon the sheep were made by Mr. E. D. Ball.

TESTING INSECTICIDES.

"Woodbury's Summer Spray" and "Woodbury's Kerosene Emulsion" were tested to determine their value for the destruction of insects, the samples being sent gratis by the manufacturers. The emulsion was of good quality, diluted readily, did not separate badly, and was used with satisfactory results upon plants for the destruction of plant lice. The "Summer Spray" which the manufacturers recommend for the destruction of "all insect pests" and which they guarantee to give better results than can be obtained from arsenical solutions, proved to be perfectly harmless to those insects to which it was applied. It was tested upon plant lice,

cherry slugs, and three species of cabbage-feeding caterpillars; namely, *Pieris rapæ*, *Plusia brassicæ*, and *Mamestra picta*, without any apparent discomfort to the insects. The manufacturers say of this spray that it "is absolutely non-poisonous" which probably accounts for its failure to harm the insects that ate it.

EXPERIMENTS IN THE APIARY.

The experiments in the apiary this year were chiefly with different kinds of foundation, including the artificial drawn foundation manufactured by The A. I. Root Company, of Medina, Ohio, with plane sections and with fence separators.

One question that has long been a matter of dispute among beekeepers seems to have been settled beyond farther question and that is in regard to bees removing wax or foundation from one place and using it in another. The experiments proved beyond question that this is done. When the bees were given heavy foundation to build comb upon, it was always thinnned but the amount of thinning varied rather widely. In some cases nearly half the weight was thinned away. Where the artificial drawn comb was used it had the septum, which is thinner than in natural comb, thickened by the bees, but the thickening was in spots and not evenly spread over the surface. It was also observed that the bees accepted the artificial drawn comb more readily than they did the ordinary foundation. They also built it rather more firmly to the sides and bottom of the section leaving fewer holes as passage ways.

The plane sections and fence separators gave excellent results. When filled with honey, the sections were particularly handsome in appearance and well filled out about the margins though the average weight was a little below the average in the old-style section which is notched above and below for a bee-space.

INSTITUTE WORK.

I have, during the past year, attended and delivered addresses at two meetings of the State Bee-keepers' Association, at the annual meeting of the State Board of Horticulture, and at two institutes, one held at Delta and one at Grand Junction.

INSECT COLLECTION.

Without making an actual count, it will be safe to say that more than 10,000 pinned insects have been added to the insect collection during the year, and far the greater part through the efforts of my assistant, Mr. E. D. Ball. These insects are chiefly in the orders *Hemiptera* and *Orthoptera.*

BULLETINS.

Two bulletins, Nos. 43 and 47, comprising 100 pages, have been issued from this Section during the past year.

Very respectfully submitted,

C. P. GILLETTE,
Entomologist.

Fort Collins, Colorado, December 8, 1898.

Report of the Chemical Section.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—The work of this Section has been continued in the lines indicated in my former reports. The Station Laboratory was moved into the new building in June last. The station work was, of course, interfered with to some extent by the moving from one building to the other and the accompanying delays subsequent to such changes.

The work on the bulletin entitled "A Soil Study," of which Part I. has already been published, has advanced at a fairly satisfactory rate considering the interruptions to which it has been subjected. The field work, in this connection, has been prosecuted this year, as it was last, on the plat of ground set aside for this purpose. Last year sugar-beets constituted the crop chosen for the experiment. The cultivation of the crop has again been carried on by this Section. The chief object has been the study of the effects of manuring with good, well-rotted sheep manure as compared with no manure or dressing of any kind, and with a dressing of straw, cut the length of about one inch. The study of the water level and the chemical composition of the ground water has been continued up to the time of harvesting the crop. The results of the study of the composition of the ground water, the composition of the soil, and the effects of the manuring upon the crop and soil will be recorded in a bulletin entitled "A Soil Study," Part II. This bulletin

will conclude the work of the Section on this subject. The time through which the study will have extended is shorter than desirable from many points of consideration, but I will have attained my object in undertaking the study, and as other work is waiting to be undertaken, it seems advisable to conclude this, or at least to record the work already accomplished and leave the further study of it till another time.

During the year, coöperative work on the general culture of sugar-beets has been carried on jointly with the Agricultural Section. Much of this work is the enlargement of the work recorded in Bulletin No. 46.

I have undertaken, in coöperation with the Botanical Section, to study the composition of the grasses of the State. The volume of my work will probably force me to confine this to a smaller number of species than may be desirable. But as this is a study which I have long considered as one which it is very desirable to make, I shall endeavor to give it as much time as can possibly be commanded for this purpose. A bulletin has already appeared on this subject, but new and fuller analyses seem desirable, therefore, I have most willingly consented to undertake the work, especially as I believe that the subject of our native forage plants is as worthy of our study as our cultivated crops.

A considerable amount of work on the artesian waters of the San Luis Valley has already been completed and should, I think, be published as an independent bulletin as soon as the remaining work can be completed.

The new Station Laboratory has proven to be very convenient and well adapted to the purposes for which it was intended. A definite measure of the volume of work accomplished by the Section may be conveyed by the fact that the number of determinations made between December 1, 1897 and December 1, 1898, amounts to thirty-nine hundred, which is to be considered in connection with the outdoor work done by my force and the delays caused by our moving from the old building into the new one.

I would not commend any increase in the working force at the present time, but I earnestly urge that it be maintained at its present number and that the salaries of the junior assistants be increased to at least six hundred dollars per annum, which is only a fair compensation for their services.

Respectfully submitted,

WM. P. HEADDEN,

Chemist.

Fort Collins, Colorado, December 9, 1898.

Report of the Section of Meteorology and Irrigation Engineering.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—The scope of the work of this Section is too well known to need recapitulation. Nevertheless its work touches that of the College in the corresponding Department under my charge in so many ways that the work of one can scarcely be mentioned without consideration of the work of the other and their mutual relations. During the year the work of this Section has been carried forward as close as possible to the general plan, and as much accomplished as the time and means at my disposal would permit. From some of the work conclusions of immediate value may be drawn during its progress, as is the case with determination of the seepage gains and losses from streams and canals; while much more requires investigations extending over several years and much labor in working out the results to obtain the most valuable results.

In a general way, it may be said that about 450 linear miles of streams have been measured during the year to determine the gains or losses from seepage, and about 100 linear miles of canals and ditches measured to investigate further the amount of losses from canals and ditches. The ordinary records in meteorology, in stream flow, in evaporation have been maintained in the vicinity of Fort Collins. Records from a number

of voluntary observers and the sub-stations have been regularly received and reduced. Most of these are near the water shed of the Cache a la Poudre river, but others have become necessary by the other investigations in progress. A study of the sub-surface waters in their relation to the surface applications by irrigation has been begun. A series of observations to determine the amount of water used in irrigation and to study the methods of irrigation has been commenced in other parts of the State. It has long been evident that the observations and measurements on the use of water in the Poudre valley needed to be checked by measurements under other conditions and in other parts of the State. The lateness of the season before this latter work could be undertaken give the results for only a part of this year, but forms a point of departure for the work of the coming year which by being begun earlier can be organized on a more extensive scale without material increase in cost.

In the prosecution of this work there has been some 3,000 miles driven by horse; some six or eight thousand miles of railroad travel, and several hundred miles by bicycle. No attempt has been made to keep account of these distances, but this estimate is believed to be below rather than above the sum total traveled by myself and assistants.

Three bulletins have been prepared during the year and seen through the press. The charts, diagrams and maps needed for the study of the data relating to a number of other topics are prepared, and many of those needed for use in future bulletins, several of which are quite advanced in their essential preparation. The amount of material now on hand furnishes the foundation for a good many. Ten years of continuous service was closed during the summer. There are thus ten years of observation carried on under the same plan and with the same purpose in view. In a number of cases the accumulation of at least ten years data has seemed desira-

ble before attempting to seriously discuss the observations and their lessons. The termination of this period now renders it possible to enter upon the reduction and discussion of certain of these lines with available opportunity.

Several years ago I took occasion to visit the irrigated regions of France, Italy and Algeria, to observe their conditions and learn what lessons drawn from their long experience would be applicable to our conditions. It was evident then, and the several years that have since elapsed have strengthened the conclusion, that in many ways our development under irrigation conditions is parallel to theirs, but that our experience is developing within a shorter period. I have gradually collected nearly all the works which would aid in the study of their irrigation, and have constantly planned to utilize the results of that visit before again passing over their ground to study some phases not sufficiently studied when there before. I am more than ever convinced of the desirability of studying their experience and rendering it available to save some of the mistakes which are constantly being made. The experience of the older countries long might have prevented the commission.

The correspondence of the year has increased considerably. The letter copying books show that the letters sent out have required about 1,200 letter pages. The inquiries received cover several phases of the irrigation question, and have been received from many states and many foreign countries. One day's mail this fall brought letters from Alberta and the N. W. Territories of Canada; from Scotland; France; and the province of Oudh, India. The correspondence received during the year includes Ontario, New Brunswick, Nova Scotia; England, Holland, Germany; Mexico and Peru; Algeria, Italy; Western Australia; Victoria; New South Wales, New Zealand, and Russia in addition.

METEOROLOGY.

The meteorological observations have been maintained with no material change. The intent has been to record the elements important in Agricultural Meteorology. These include rainfall, moisture, humidity, temperature, cloudiness, evaporation, wind, air pressure, soil temperature, etc. Such observations need to be maintained for a series of years before the averages are of any great value in determining the normals for the climate.

To determine our rainfall normal at this place, we now have twenty years' observations for most months. The normal thus obtained for the whole year is 13.26 inches. Treating the observations by the method of least squares, it is found that it is an even chance that in a longer series of years, the normal is .62 greater or less than this. It is thus probable that with a longer series of observations the annual will not be found to be lower than 13.24, or more than 14.24 inches. For single years it is an even chance that the total will be as low as 11.64 or as great as 16.08 inches.

In a number of special lines, some attempt has been made looking forward to special study for separate application as to soil temperatures, evaporation, etc. The character of the observations themselves has been shown in the annual reports hitherto given up to 1891, after which date, according to the request of the Director as stated in the report for 1893, they were omitted.

SUNSHINE.

In the Agricultural applications of Meteorology, as well as from its climatic and sanitary aspects, the amount and intensity of the sunshine, is one of the most important of the elements to measure. The energy which exhibits itself in the growth of plants, is derived principally from the heat received from the sun and is converted into the forms of plant growth. The relation is obscure,

but there is no question but that there is such a relation, and the only way to find it is to make attempts with that purpose in view. Records of the sunshine have been maintained during the past nine years, but available time has not permitted the measurements of the sheets, except those of a few years. There is now enough data on hand to warrant a more careful study. During the past summer some progress was made in measuring and reducing these measurements with the intention of bringing the ten years' observations, with the several years' records at the sub-station, into form for publication in a bulletin on "Sunshine in Colorado." The records are not completed, and probably a couple of months of continuous work will be required to complete the measurements, and at present without additional help, this cannot be done.

Observations along the same line to determine the intensity of sunshine have been carried on for some years. Additional observations to determine the intensity at high elevations were made at altitudes of 9,000 feet and over 14,000 feet during the summer, but were incomplete, from the disabling of one set of actinometers, and from taking but a short "vacation," in which such observations could be made. We now have sufficient data to make an instructive bulletin and probably to clear the ground for more systematic work along the related lines.

SOIL MOISTURE.

Early in the year, an instrument of the Whitney pattern, to determine the temperature and amount of moisture in the soil was ordered, and the instrument was received in the summer. The instrument is intended to determine the temperature by the change in electrical resistance with the change in temperature, the material used being a solution of salt. The amount of moisture is also determined by its effect upon the electrical resistance, the less the moisture the greater being the re-

sistance. An alternating electric current is used and the resistance found by the use of a rheostat.

Before placing the instruments in the soil, it seemed desirable to thoroughly test the tabulated temperature corrections, and determine the accuracy of the apparatus. The resistance of these temperature cells ranges from 1,400 to 2,000 ohms, at 60°, and the change for one degree of temperature is from 5 to 20 ohms per degree, within the range of our temperature changes. As this is a variation which can be determined by ordinary means of measurement, it was at first hoped that these instruments would furnish the means for much more sensitive determinations of soil temperatures than the thermometers hitherto in use, and when once provided with a rheostat box, the expense of additional tubes would be nominal. The accuracy has not, however, been as great as hoped for.

Probably three weeks were taken in these tests by Mr. Stannard. The results were disappointing so far as leading to any very accurate results. Single readings varied at times over two degrees from the correct temperature.

WATER SUPPLY.

Continued record and study has been made on the Poudre river, the stream nearest to our door and which is typical of the streams which supply nearly all of the water for irrigation in Colorado. Its study has thus been of more than local application. We now have fifteen years of continuous record, for most of the time made with the self registering instrument, and thus have not only a longer but a more complete record than any other stream in the West. Additional attention has been given during part of the time to the questions pertaining to the watershed, and rain-gages have been put in the hands of observers who would furnish observations on rainfall. It has been difficult to find people who lived where such observations were desirable, and to find those who would be interested in tak-

ing them. But the data thus obtained is of value not only for this stream, but as an indication of the fluctuations in the other streams in the State. The general conditions which cause high or low water are more than local, so that it is often the case that the various streams reach high water on the same day.

The sheets on the instruments have been changed weekly, requiring a visit to our rating station, which is about fourteen miles from the College. The results of these weekly records have been furnished in manuscript or mimeograph copies to the papers in northern Colorado, and for a portion of the year, through the courtesy of the Fort Collins Courier, printed slips have been sent to other papers. The reports have been furnished to the papers in northern Colorado and to a number of ditch companies or those specially interested in the distribution of water. Altogether 28 of such weekly reports have been issued. These have been printed widely in the local papers and in the Denver dailies, and occasionally in papers as far south as Pueblo. The weekly distribution of the report has thus sometimes reached as high as 150,000 copies. These reports were begun some five or six years ago as a matter of accommodation to the local irrigation interests. As the printed slips have been furnished gratuitously, I could not urge the printing office to lay aside profitable work to print them. In consequence the reports have sometimes not been distributed until too late in the week to reach some journals before their day of publication, and therefore have not been as useful as they would otherwise have been.

There is no good reason why these slips should not be printed as special bulletins of the Experiment Station, and thus distributed under the Station frank. By so doing a small sum that is now expended for postage can be paid to the printing office, and we can consistently expect that the printing will be done promptly. Thus without greater expense than at present they may be made more useful, and the distribution can also be made more

widely than at the present, when from 40 to 80 copies are distributed weekly.

A portion of the last weekly bulletin of the year of more than ephemeral value is herewith given.

"The year 1898 has been exceptionally low in its water supply. The small amount of snowfall in the mountains last winter gave indication of this and the little which fell early in the winter gave reason to expect that the late water would be unusually low, unless maintained by storms. These were the general features of the year, and while the rains of May were abundant the dry ground absorbed a large proportion of the rainfall, and a relatively small amount reached the river. Fortunately, storms have helped out the year to some extent on the Poudre, but not so much as on the Arkansas; nevertheless the stream has been abnormally low.

Since the early settlement the areas of forest have become much less from fires, and by denudation for mining and railroad purposes. The amount used for domestic purposes is of small importance, except as careless and irresponsible cutting gives conditions favoring the start and spread of the devastating forest fires. From the standpoint of the water supply on which our agriculture depends, the protection of the forests becomes of vital importance. The protecting influence of the forests on the snow cover is of the greatest importance. The letting in of the sun and wind melts and evaporates the snow without sensible formation of water, dries the springs and lessens the amount of water available for use. It is safe to say that with the former forest cover, even with the small snowfall and little rainfall of the past year, the low stage of the river would not have fallen to 34 feet as it did this year. It would have been several times more, for the innumerable small springs would have continued their supply. If the forest cover continues to be removed, autumns of low water like the present will cease to be exceptional, but become the rule, the river will be lower than it has been this year, and may become as dry as some of its tributaries.

During the current year, starting with an average of 184 second feet for the week ending April 26, the river rapidly rose after the middle of May. The highest of the year was the week of June 21, which averaged 1543 feet. Then the river rapidly dropped, the next week to 1200 feet, and the week following to 744 feet. By August 1, there was only 220 feet. Early in September there was only 100 feet, and by October 1 it had reached the unprecedented low stage of 34 cubic feet per second. After a couple of weeks the early snows in the mountains had the effect of raising the river.

In comparing with previous years it is instructive to compare with the high water and with the average for the whole season.

Taking the record by years, the closing dates of the weeks of high water and the average for the week have been given as below. The dates of high water are the resultant of the amount of snow, the periods of warm weather, and the effects of rains, and no attempt to distinguish the causes is made.

Year.	Week Ending.	Average for Week.
1884	June 14	5071
——	June 28	5075
1885	June 7	3330
1886	May 31	2439
——	June 14	2420
1887	June 7	2400
1888	June 14	1210
1889	June 7	1545
1890	May 31	1592
1891	June 14	2692
1892	June 28	2057
1893	June 14	2445
1894	June 7	3196
1895	June 14	2914
1896	May 31	1736
1897	June 14	2220
1898	June 21	1543

The average for the 27 weeks of 1898, from April 26 to November 1, has been 451 cubic feet per second, an amount less than for any other year of which we have record except 1888, when the average fell to 400 cubic feet per second. After the middle of July the river fell lower than in 1888, the higher average being due to the higher water in May and June.

For the period of 27 weeks the record in the different years has been as follows:

Year.	April 26 to Nov. 1.
1884	1761
1885	1196
1886	747
1887	720
1888	400
1889	482
1890	567
1891	671
1892....(May 17 to September 6, only)	753
1893....(May 10 to September 6, only)	815
1894	804
1895	914
1896	520
1897	793
1898	451

The year 1898 has thus averaged but little over one-fourth of the amount received in 1884 for the corresponding time and if deduction be made of the water received from other watersheds it would be less than one-fourth.

The river water of 1898, during this 27 weeks, if applied to the whole of the irrigated area of the valley, which may be called 130,000 acres, would cover it to a depth of about 16 inches. The rainfall during the same time has been about 8 inches, or the total moisture has amounted to about 24 inches, which would be increased by the amount stored in the various reservoirs during the winter and spring."

It has been increasingly evident that in the study of many of the questions of irrigation, a simultaneous study of the water conditions below the surface of the soil, and of the quantities and times of application of water at the surface is needed. It was mentioned in the last report that continuous records had been maintained for several years of the height of the ground water in a disused well, and records on small holes of a moderate depth near by. During the present season, a similar trial has been made on a larger scale, a series of wells extending to the foot hills four miles away, being taken. Wells already sunk were used. Their elevations were obtained by running a line of levels connecting them. The distance from the surface of the water was determined weekly. The uppermost well was above irrigation ditches. The trial was tentative to find out the character of the questions involved and to determine what might be expected to be settled by such an inquiry, if carried out more fully. Enough is found to show that valuable information can be obtained by extending such an inquiry over a more extended area and made more complete, according to the topography, examining at the same time the canals and the irrigation records of the tracts. Such a record is very desirable in connection with the duty of water in irrigation and before the last word is said on the subject, such an investigation will be necessary.

The following table shows the weekly changes in level in the water surface. Some of the more marked changes of level are due to the irrigation of lands near the well.

Poore's well is above all irrigation, and as shown in the notes the water table is a considerable distance from the surface of the ground.

MEASUREMENTS OF WATER SURFACE.

(IN FACT.)

Date.	Miller's.	Parsons.	Harris.	Zenner.	Andrews.	Ward's.	Poore's.
April 13							
April 19	0	......	— .30	......	+ .47	+1.63	+ .03
April 26	+ .02	— .14	— .10	+3.13	+ .48	— .15	+ .00
May 6	+ .56	— .11	+1.23	+3.67	+ .58	— .65	— .22
May 13	+ .60	— .05	— .13	+ .43	+6.10	+ .34	— .04
May 20	+ .39	+ .09	+ .80	+ .41	—5.46	+ .59	+ .09
May 27	+ .45	+ .13	+ .57	— .26	+ .18	+ .49	— .04
June 3	+ .25	+ .24	+ .45	— .67	— .04	+ .35	— .01
June 10	+ .28	+1.38	+ .30	+ .25	— .32	+1.27	— .04
June 16	+ .12	+ .48	+ .15	— .86	— .07	+ .54	— .10
June 24	+2.47	+1.24	+ .50	+ .03	— .23	— .27	+ .08
June 30	+ .21	+ .50	+ .56	— .40	+1.17	+ .48	— .00
July 7	— .70	+ .18	+ .78	— .31	—0.62	+ .54	— .08
July 14	— .05	+ .26	+ .56	— .30	+ .79	— .48	— .00
July 22	— .78	+ .37	+ .88	— .34	— .61	—1.16	+ .03
July 28	— .61	0	+ .41	— .25	— .59	— .39	— .01
August 4	— .50	— .01	+ .07	— .22	— .59	— .09	+ .05
August 13	+ .55	— .07	+ .57	+ .75	— .28	— .28	+ .09
August 18	—1.33	— .13	+ .02	+ .15	— .58	— .15	— .27
August 26	— .43	— .37	— .04	— .07	— .35	— .45	0
September 2	— .04	— .35	— .34	+ .03	— .35	— .03	+ .06
September 17	— .70	— .69	— .73	+ .04	— .68	— .90	— .03
September 24	— .30	— .26	— .51	— .15	— .01	— .43	+ .01
October 4	— .35	— .38	— .68	+ .30	— .05	— .65	— .01
October 11	— .15	— .08	— .41	— .08	— .59	— .07	— .01
October 18	+ .66	— .25	— .35	— .17	— .32	— .19	+ .07
October 25	+ .65	— .24	— .39	— .23	+ .04		— .13
November 1	— .05	— .10	— .30	— .06	— .03		+ .07
November 11	— .27	— .22	— .50	+ .43	+ .40		+ .01
November 18	— .18	— .15	— .31	+ .20	+ .13		— .02
November 25	— .14	— .14	— .47	+ .09	+ .10		+ .01

Miller's well, observations generally taken 8-9 a. m. Distance to water from point 2 in. above ground at first observation, 11.81; at last observation, 11.18.

Parsons's well, observations generally taken 8-9 a. m. Distance to water from point 3 ft. above ground at first observation, 20.96; at last observation, 19.83.

Harris's well, observations generally taken 8-9 a. m. Distance to water from point 3 ft. 6 in. above ground at first observation, 23.85; at last observation, 21.56.

Zenner's well, observations generally taken 8:15-9:15 a. m. Distance to water from point 3¾ ft. above ground at first observation, 11.96; at last observaticn, 6.42.

Andrew's well, observations generally taken 8:30-9:30 a. m. Distance to water from point 3 in. above ground at first observation, 20.11; at last observation, 21.44.

Ward's well, observations generally taken 8:40-9:40 a. m. Distance to water at first observation, 4.58; at last observation, 4.69. Measured from point about 6 feet below general surface level.

Poore's well, observations generally taken 9-10 a. m. Distance to water from point 3 in. above ground at first observation, 29.93; at last observation, 30.34.

DUTY OF WATER.

Observations have been continued looking toward the further determination of the amount of water used in irrigation. These have included the continuance of the observations on a farm of 160 acres under the direction of J. H. McClelland of Fort Collins, devoted to mixed crops and on a native meadow belonging to Capt. W. M. Post of Fort Collins, both of which have been used for this purpose for the past eight years. Owing to change of management, other farms in the vicinity of the Agricultural College used in previous years were not used for this purpose this season. Three of the instruments which have been used to record the amount of water were transferred to the Arkansas valley. We were then fortunate in obtaining the aid of some of the most successful and widely known horticulturists in the valley. Measurements were maintained at Cañon City on one of the largest orchards of that region, belonging to Hon. B. F. Rockafellow, also on a part of the Frederica mesa under the Bessemer ditch near Pueblo; at Rocky Ford on a portion of the fruit farm belonging to Hon. J. H. Crowley, on a portion of the sub-station farm of the Experiment Station under the superintend-

ence of H. H. Griffin; and at Holly on the newly established fruit farm of W. F. Crowley.

The valley at Cañon City is at the base of the mountains, and is widely known for its fruit interests. The orchard of Mr. Rockafellow is one of the oldest and finest of that region. It is devoted to apples, cherries, grapes, etc., principally, and has been in bearing for several years, its commercial success being well known. The water used on 41 acres was measured. A flume was put in place and a recording instrument, being attended by Philip Sheridan, who had immediate oversight of the place and attended to its irrigation. The soil is heavy. Across the river on the south side the soil is of quite a different character, being much lighter. It was hoped to conduct similar measurements under those conditions at the same time, but the lateness in organizing the work precluded an attempt this year. Arrangements are made for next year, however, whereby it is expected to have the use of the fruit lands on that side in comparison.

In addition, the Fruitland Ditch Co. at Cañon City were kind enough to supply full information of the amount used by them day by day throughout the year, and also for the previous years since their pumping plant —said to be the largest west of the Missouri river—has been in operation.

The fruit farm of J. H. Crowley at Rocky Ford is well known. A portion of mature trees, including apple, plum, cherry, peach, is situated close to one canal, not convenient for measurements. A part, about 23 acres above the canal mentioned but below another canal, was more conveniently located for such purpose. This portion, planted to fruit for a few years, was kindly furnished by Mr. Crowley.

This orchard gave one of the clearest instances of the effect of cultivation in conserving moisture as shown by its effect on the growth of the trees that I have seen.

The Experiment Station farm or as much as could be supplied through one measuring box was used, and the record kept by Mr. Griffin.

On the Frederica mesa a tract of 219 acres was kindly placed at our disposal by the kindness of Mr. C. K. McHarg. A box was put in place by Mr. Hawley and the measurements made by Mr. Petrie.

Mr. W. F. Crowley, the superintendent of the Arkansas Valley sub-station in 1897 and formerly well known as a young horticulturist of great activity and promise, started an orchard on the plains north of Holly and under the Amity Canal early in the Spring. I had happened to see the tract of land as it lay in unbroken prairie but a short time before. It is generally believed that the need of land for water becomes less after a few years. This was an excellent opportunity to observe the change, if any from the first use of water. Mr. Crowley took a keen interest in the attempt, putting in the box and caring for the instrument. Mr. Crowley is a skillful irrigator and the results of the measurements will be of great interest. As there had been no previous irrigation given in the immediate vicinity, it affords a model case of original irrigation. The only draw-back is that it is over 300 miles from the Home station, and the opportunities for examination are not so frequent as desirable.

A survey and topographical map has been made of each of the tracts thus used during the past year, and will form the basis of the more detailed measurements for the next year, which is hoped to begin earlier in the year, in order to include all of the irrigation season.

None of the measuring weirs or instruments could be put in place as early the past season as desired, as the question whether funds could be used for the purpose was not decided until July.

By that time the most important irrigations of the season were over, and the results that we obtained are only for a portion of the year. They however will show the amount of water used in these special irrigations and give means of estimating the amount used for the whole season. They will insure that tracts with boxes in place will be ready for next season's operation. These meas-

urements need to be carried on more extensively and are very desirable to extend.

In addition to the tracts above mentioned, the information from other sources, as from ditch companies that maintain a system of measurement will materially increase the amount of data available.

At this date the observations resulting are not reduced and the results of the determination cannot be given. We have now some six years' continuous observations since the Bulletin 22 on "The duty of Water" was published in 1892, enough to warrant another and more extensive investigation of the data at hand.

SEEPAGE MEASUREMENTS.

We have made in round numbers some 1,200 linear miles of river measurement to determine the loss or gain from seepage since bulletin No. 33 was published on this subject in 1896. These measurements have included three on the Poudre, one on the Platte in connection with the State Engineer's office, two on the Arkansas from the mountains to the State line, three on the Rio Grande in Colorado, two on the Big Thompson and the Little Thompson, and one on the St. Vrain.

The first measurements on the Big Thompson and on the Arkansas were made in 1897, on the St. Vrain, in 1898. We have found from experience that the first year's measurement is usually defective, the first trip being required to learn the location of the headgates, the roads or paths to get to them, the location of the wastegates, and in general obtaining the detailed local knowledge necessary to prevent oversight of important points, or in order to select the most desirable points for gaging, accessibility and topographical features being considered. The Water Commissioner usually possesses this detailed knowledge in his district. Still we have often had occasion to visit ditches which the Commissioner had never seen, the ditch perhaps having an early appropriation and thus requiring no regulation

from the Commissioner. We have sometimes found disturbances brought in from wastegates which had been overlooked by not learning that there were several sets. The measurements after the first year have usually been free from such errors.

At the time of writing the last annual report late in November, 1897, the measurements were reported in progress on the Arkansas river. The river at that time contained considerable water and was at times difficult, if not dangerous to wade. The water was sometimes breast deep. The temperature was low, and before the 200 miles were completed the water was at freezing temperatures and running slush ice. At one place the observer lost his footing and was entirely submerged.

The work was simultaneously carried on in two field parties. I was able to do but little myself, the first attempt in October having been stopped by a heavy storm. The measurement of 1898 was more satisfactory, both because of the detailed knowledge gained in 1897, and because the river being lower the gagings were more easily made by wading.

From Cañon City to Pueblo, a distance of 40 miles, for a large part of the way the river is in a chasm with no wagon road convenient to the river. The measurement was made by covering the distance on bicycles along the railroad grade. Below Pueblo horses were used and the assistance of Water Commissioners Reece and Cressey and of the Fort Lyons, Lamar and Amity Canal companies through P. J. Preston, A. E. Bent and W. M. Wiley, is gratefully acknowledged.

I was able to pass personally over the ground in detail for most of the distance from Cañon City to the State line. I gave more particular attention to the conditions affecting seepage, and to a study of the geological stratigraphy as it bears on seepage, and find a close relation between the rock strata and the gain and losses from the river.

Wherever the drainage of an important watershed discharged into the main river, it was desired to take a

measurement both above and below to obtain a measurement of the water entering the stream in the sands, if any such existed.

Before starting the measurement, the names and the location of the headgates were determined as far as possible, and from general knowledge of the country and from the topographical maps, which though often seriously incorrect, were found useful. The points of gaging were selected. Blue prints were made showing the available information, and typewritten sheets of instruction of which the following is an example, were given to the observers.

The points selected for gaging stations were chosen from their accessibility, from their being critical points in the topography, or at some place where the information was desirable, as at the head of important ditches.

INSTRUCTIONS IN SEEPAGE MEASUREMENTS, DISTRICT 14.

Water District No. 14, Carlile Springs to Nepesta.

River gaging No. 4. At Carlile Springs, on west side of Pueblo County.

No. 5. Head of Bessemer ditch, distance 9 miles.

No. 6. At Rock Cañon, distance 4 miles.

No. 7. Above Pueblo, about opposite or a little below the Insane Asylum, distance 5 miles.

Gage Fountain creek at its mouth.

No. 8. Below the Fountain, and below Pueblo. This should be about a mile below the Fountain, or if the roads are more convenient, about two miles. According to the map the road seems to reach the river on the north side about two miles below the mouth.

Gage the St. Charles near its mouth.

The St. Charles needs to be gaged above the Bessemer ditch; this can probably be done by L. G. C.

No. 9. Gage the river below the St. Charles, distance 6 miles. This can be at the road crossing about a mile below the St. Charles.

No. 10. Above the Huerfano, above the plain formed by the river. Gage the Huerfano, or see the amount of water it contains. It will probably be dry.

No. 11. Gage below the Huerfano. A favorable place about a mile below, near the head of Bob Creek Canal, or, better, a little lower yet.

No. 12. The river at Nepesta at or above the railroad bridge.

No. 13. Head of the Otero Canal. Measure all streams going in, and all canals taking water out.

MEMORANDUM OF DITCHES, IN ORDER, ALONG THE RIVER.

No. of Section.	Range of Township.	Name of Ditch.	Side of River.
1	68	Hobson	North
16	67	Fields	North
15		Ritchie	South
23		Brooks	South
33	66	Bessemer	South
36		Hampbell	South
31	65	West Pueblo	North
27		Morey	North
27		Haden	North
34		Riverview	South
34	65	Pueblo Water Cos	South
4	64	Barnum	South
18	64	The Arkansas	North
16		I. N. Sater	South
32		The Booth	North
35		Warrant, Barnes & Baxter	North
32	63	Excelsior	North
6	62	Ballow Hill	North
8		Collier	South
10		Colo. Canal (Bob Creek)	North
1		Arkansas Valley	North
17	61	Rocky Ford High Line	South

No. of Section.	Name of Township.	Name of Ditch.	Side of River.
16		Allen	South
31	60	Enterprise	North
31		Oxford Farmers	South

SEEPAGE GAINS AND LOSSES, ARKANSAS RIVER.

The following summary shows the seepage gains and losses that were found on the Arkansas river in 1897 and 1898, the measurements being given in cubic feet per second.

Place.	Dist. Miles.	Area of Tribut'y Water-shed Sq. Miles	1897. Gain. Sec.	1897. Loss. Ft.	1898. Gain. Sec.	1898. Loss. Ft.
Canon City to Bessemer ditch	33	1,481	54.40	....	55.17	....
Bessemer to Pueblo	10	255	....	42.18	....	15.96
Pueblo to Orchard Grove	8	1,101	....	9.40	19.41	....
Orchard Grove to Boone	16	1,335	103.47*	....	20.30	....
Boone to Nepesta	10	2,235	40.44	....	....	17.65
Nepesta to Otero Canal	8	182	....	5.78	....	11.00
Otero Canal to Apishapa Creek	7	57	16.90	....	18.15	....
Apishapa Creek to Rocky Ford	16½	1,667	30.55	....	31.21	....
Rocky Ford to Fort Lyon Canal	9	749	35.59	....	22.39	....
Fort Lyon Canal to La Junta	3	88	13.04	....	8.20	....
La Junta to Jones Ditch	11	115	10.85	....	14.76	....
Jones Ditch to Las Animas	9	193	28.51	....	20.08	....
Las Animas to Old Fort Lyon	6	3,509	38.14	....	13.26	....
Old Fort Lyon to Caddoa	11	660	3.63	....	....	0.16
Caddoa to Amity Canal	10	445	....	....	....	6.64
Amity to Lamar	11	256	....	....	6.68	....
Lamar to Holly	30	461	13.21	....	14.20	....
Holly to Coolidge, Kansas	7	1,171	....	....	....	....
Total	215	15,960	387.43	57.36	243.81	51.41
			57.36		51.41	
			330.07*		192.40	

*Evident error.

* Assuming the result of 1898 from Orchard Grove to Boone as correct, the gain would be 250 ft.

The river as it crosses Colorado, passes through several basins caused by the folding of the rocks. The larger one has its western rim at Rock Cañon, a few miles west of Pueblo, and the eastern rim near Old Fort Lyon, about 15 miles east. The rocks also dip to the north away from the river. The significance of this latter condition, is, that so far as the water penetrates these rocks it does not return to the river, but is lost to the agriculture of the valley. If the water thus taken up is considerable, it means a serious loss to the valley.

Practically the measures seem to indicate that at the places of cutting through the sandstones above Pueblo and from Old Fort Lyon to the Amity Canal, there is a loss, while in between there is a gain with few exceptions.

My studies on this point this year have not been extensive or detailed enough to warrant any conclusive statement further than to say, that the facts so far found seem to indicate that this loss is not so serious as has been feared. The conditions of the north side of the river especially under the larger canals, like the Colorado, the Holbrook, the Fort Lyons and the Amity, need to be examined more in detail for evidence bearing on this subject.

On the Platte the understanding with the State Engineer was that his office would make the measurement in 1897, and he was preparing to make it in 1898. We coöperated in the measurement in 1896. I wish to make a further examination of this valley giving more special attention to the conditions relating to seepage, before publishing the results made since those detailed in Bulletin 33. The conclusions there given have been strengthened by the subsequent development.

SEEPAGE MEASUREMENTS ON THE BIG THOMPSON.

The measurement for seepage on the Big Thompson and Little Thompson were referred to in the last annual report. The measurement in 1898 was postponed beyond

the time desired, because the water was being changed from one ditch to another giving daily a new condition of the river outflow. Until the conditions became more stable it seemed useless to make the measure. The valley is one of the oldest in the state. Some water from this stream irrigates area which is tributary to the Poudre river and a little land tributary to the Little Thompson is irrigated by water from the St. Vrain.

The following is a summary of the results of the two years.

	1897.	1898.	Distance. Miles.
Handy to the Home Supply Canal	0	....	1.0
Home Supply to the Barnes Ditch	15.78	8.13	5.7
Barnes Ditch to the Loveland & Greeley	4.62	3.52	3.1
Loveland & Greeley to the Big Thompson Ditch	12.38	13.31	10.5
Big Thompson Ditch to the Hill & Brush	4.52	6.62	5.3
Hill & Brush to the Big Thompson & Platte	12.42	9.59	10.6
Big Thompson & Platte to the Evanstown Ditch	14.36	11.59	11
Total	64.08	52.74	47

ON THE LITTLE THOMPSON.

	1897.	1898.
From Eagle Ditch to Dry Creek	1.35	3.16
Dry Creek to Rockwell Ditch	2.77	1.52
Rockwell to Miner Ditch	2.43	1.32
Miner Ditch to Mouth	4.08	2.89
Total	10.63	8.89
Total for both Big and Little Thompson	74.71	61.63

It is noticed that the increase in 1898 is less than in 1897, probably due to the smaller water supply in the past year. The measurements are given in cubic feet per second.

ON THE ST. VRAIN.

The St. Vrain creek rises in the high mass of mountains from the south slope of Longs Peak southward to the headwaters of Boulder creek, and waters one of the most fertile of the tributary valleys of the Platte.

The following were the gains found in the measurement made Oct. 26-28, 1898 by Mr. Trimble with the aid of Mr. L. H. Dickson of Longmont, Water Commissioner of Water District No. 5.

	Distance, miles.	Gain, sec. ft.
From Lyons to the Oligarchy Ditch	3.7	2.63
From the Oligarchy to the Niwot ditch	2.7	3.24
From the Niwot to the Boulder-Weld Co. line	6.7	7.39
Co. line to Boulder creek	2.2	5.34
Boulder creek to Fleming place	5.8	4.21
Fleming place to Platte river	7.0	2.98
Total	28	25.79

This does not include the seepage return entering Left Hand creek, a tributary of the St. Vrain and which is supplied with water by ditches from the St. Vrain principally, nor seepage entering Boulder creek. Both of these streams need to be measured to include the return waters from their water sheds.

The amount of land irrigated from the St. Vrain is approximately 89,000 acres according to the report of Water Commissioner Dickson.

THE RIO GRANDE RIVER IN COLORADO.

A measurement to determine seepage on the Rio Grande was made in 1897, this being the third year of measurement and the results are satisfactory. The measurement of this year again shows that the losses from the river in the upper part equal or exceed the subsequent gains of the remainder of the river in Colorado. I have attempted to get information bearing on the con-

ditions south of the San Luis valley which should confirm or disprove the hypothesis I had formed to explain the excessive loss, indicated by the loss from the river and by the disappearance of the numerous side streams. In 1896, I crossed the valley at the lower end and in 1897 took a hurried trip as far as Santa Fe, New Mexico, and crossed the valley in the vicinity of Espanola. Now it seems desirable to pass lengthwise of the valley from San Luis to Taos. The country is very sparsely settled and is mostly a barren country. By correspondence, I have been able so far to obtain little definite information which would serve to narrow the search for indications thought to be there.

In the measurement of the Rio Grande in 1898, it is noticed that the river begins to gain, or perhaps it would be better to say ceases to lose, at a point higher up than was noticed in 1896. Whether this is the effect of some fluctuation in the river or is an actual fact, is an important question. If the latter, it is significant in interpreting the greater amount of water taken by the valley. As this was not noticed in comparing the observations of 1896 and 1897, it emphasizes the need of caution in drawing conclusions before sufficient data is accumulated. Desire is sometimes expressed for results to be published before sufficient data is at hand, but it may be said that unless there are enough and long enough continued observations to make the conclusions more than probable, publication is apt to be more harmful than beneficial.

	Gain in 1898.
From gaging station to Del Norte	—51.69
Del Norte to Prairie Canal	+ 2.11
Prairie to Monte Vista bridge	+ 6.26
Monte Vista to Kenilworth ditch	+ 8.82
Kenilworth to Hickory Jackson ditch	+18.10
H. Jackson to Alamosa	+ 2.78
Alamosa to Conejos river	+ 1.57
Conejos to Lava canon	— .92
Total loss	13.17

The measurement in 1898 was made from Aug. 19 to 25 by Mr. J. D. Stannard aided by Water Commissioner M. D. Blakey of Monte Vista. The last measurement was below the Mexican village of Los Sauses where the river enters a cañon.

CACHE LA POUDRE RIVER.

	1896. November.	1897. October.	1898. August.
Weir to Fort Collins Water Works	— 2.92	+ 1.39	— 7.76
La Porte to Larimer and Weld Canal	?		+ 0.41
Water Works to La Port		16.61	+ 8.75
Larimer and Weld Canal to No. 2 Reservoir Supply	— 5.68	— 3.96	+ 3.37
To Strauss Bridge	—22.87	— 2.90	+14.84
Strauss Bridge to No. 2 Canal	+16.41	+10.42	+ 1.28
No. 2 Canal to Eaton Ditch	+10.42	+13.36	+ 8.34
Eaton Ditch to Greeley No. 3 Canal	+ 5.77	+35.72	+15.44
No. 3 to Greeley Mill Power Canal	+16.64	?	+21.16
Mill Power Canal to Camp Bros. Ditch	+25.52	+26.57	+25.98
Camp Ditch to Mouth	+21.98	+23.58	33.37
Total			135.18

In 1898 measurement made Aug. 9-12 by R. E. Trimble and Prof. G. L. Swendsen Aug. 9-10, and the remainder by R. E. Trimble and J. C. Mulder.

In 1897, the measurements were made Oct. 7-14, by R. E. Trimble and R. Q. Tenney.

In 1896, the measurements were made Nov. 11-14 by R. E. Trimble and R. W. Hawley. Water was being changed from power to canal purposes and from night to day, causing fluctuation in the river and throwing doubt on one of the upper sections.

LOSSES FROM DITCHES AND CANALS.

Bulletin 48, issued in July, on "The Losses from Ditches," was intended to call attention to a source of loss whose extent had been little realized by the agricul-

tural community, to arouse attention to its importance, and to point out some practicable methods of lessening it. The importance of this source of loss is evident when we consider that from one-fourth to two-thirds of the water resources of every ditch is wasted without beneficial use. In one ditch measured this summer, which pumps water over 100 feet high, one-fourth of all the water is lost in the first half mile of ditch. It therefore takes one-fourth of all their coal to supply the waste in this extent of ditch. In another case the loss has amounted to 18 to 20 feet in depth at places.

As opportunity served during the year, additional measures of this type have been made, mostly on ditches in the Arkansas valley. This included a number of ditches around Cañon City and the determination of the losses on the whole length of the Bessemer ditch. As it will be some time before the subject is taken up in the form of a bulletin, some of the measurements are here given.

ORIGIN OF SEEPAGE WATER.

In the case of the Bessemer ditch, which extends some ten miles above Pueblo to about twenty miles below, the conditions are unique and are such as to enable a determination to be made of the amount of water entering the river from seepage from the canal and the land which it waters. In almost every case in the state it is difficult to determine the origin of the return water because several ditches are found one above the other, and the source of the seepage that is found thus becomes doubtful. Even in those cases where there is but one ditch, it is not at all sure that all of the water entering the river comes from this ditch, or that all of the water coming from the ditch is collected in a given stretch in the river. In the case of the Bessemer ditch, however, the mesa over which it extends is underlaid with a stratum of shale rock which slopes towards the river and forms a shelf along the bluffs of the river for the whole length of

the ditch. It thus forces all the seepage to the surface, renders it evident, causes it to collect in streams at the edge of the bluffs and thus permits it to be measured. The opportunity was too exceptional to omit taking advantage of it, and in 1897 the measurement was made by Mr. Trimble from Pueblo to Grant Arroyo, and in the fall of 1898 by Mr. Hawley for the whole distance. It was necessary to walk most of the distance. Without entering into detailed statement of the measurements, it is sufficient to say that about one-half of the amount of water entering the river is derived from the losses from the ditch itself, the other half being supplied by the water which is applied to the farms by the farmers. When the whole conditions are taken into account and the flow throughout the year is considered, it is possible that the amount coming from the ditch will not be as large a proportion of the whole year's inflow, as during the irrigation season.

The general result is borne out by the measurement made in the valley around Cañon City. In this case the losses from the various ditches were measured and the gain of the corresponding stretch of the main river. The gain in the river was found to be about twice the loss in the ditches. This measurement is not so conclusive as in the case of the Bessemer ditch, because of the uncertainties in the measurement of the river and from several other conditions.

Some systematic attempt was made during the year to obtain photographs showing the methods of irrigation with view to use in connection with studies that have been more or less systematically made for a number of seasons. We have found in the past that when postponed until the latter part of the summer, as the demands of field work at the earlier part of the season has usually required, the growth of plants and weeds have prevented obtaining successful photographs. It is both hard to find the conditions which shall clearly show the points desired, to find the application of water and to find the state of vegetation such as to exhibit the meth-

ods desired. In the several days' trip made for this special purpose, a few, but only a few, successful photographs were obtained.

ACKNOWLEDGMENTS.

The work of the Section could not have been as successful without the conscientious work of those connected with the department: Mr. R. E. Trimble, assistant in the Experiment Station, on whom has devolved the details of the local observations at Fort Collins, and much of the reduction; Mr. J. D. Stannard, assistant in the College, who has helped with some charts and with the seepage measurements in the San Luis valley; R. W. Hawley, who aided in the field in the Arkansas valley from July to December; J. C. Mulder, principally in office draughting during the summer vacation; W. R. Headden, in office work for a couple of months during the summer, and Miss Ella Goldsborough, for typewriting services during the rest of the year.

We are indebted to many throughout the State for material services, rendered at considerable expense of time and expense to forward the investigations in progress. Among these are Henry Earle, manager of the Fruitland Ditch, who has materially helped with obtaining valuable information and freely placed the records of his company at my service; Dr. J. L. Prentiss, also of Cañon City, proprietor of the Hot Springs Hotel, who has taken daily samples of water for the determination of sediment; Philip Sheridan, in charge of the irrigation of the orchard of Hon. B. F. Rockafellow at Cañon City, who has taken care of the instrument and record intended to record the water used in irrigation; Hon. B. F. Rockafellow, for the use of his orchard as a field for observation. At Pueblo Mr. C. K. McHarg, manager of the Bessemer ditch, and Hon. J. S. Greene, ex-State Engineer, took active interest in the measurements and investigations and were instrumental in having land placed at our disposal, as well as aiding with the Bessemer

ditch; Water Commissioner Reece, who has not only aided with records, but assisted for several days in the seepage determinations along the river; Mr. Bentley, superintendent of the Bessemer ditch, also gave material aid, as did Messrs. Taylor and Keasby, of Vinland, in the arrangements for determining the duty of water. At Boone, Messrs. Philip and —— Burton, Deputy Water Commissioner, aided in the stretch of the river to Nepesta. At Manzanola, Mr. M. D. Lyle, superintendent of the Fowler ditch; in water district 17, S. W. Cressey, Water Commissioner for that district, actively aided in person and with vehicle in the measurements; Hon. J. H. Crowley, in the use of his orchard and in many other ways; Mr. Harvey Griffin, superintendent of the Arkansas Sub-Experiment Station; and the Hon. A. L. Kellogg, President of the State Board of Agriculture, whose intelligent interest helped in rendering the work possible.

At Las Animas Mr. P. J. Preston, superintendent of the Fort Lyon Canal system, one of the longest in the United States, and Mr. C. W. Beach, an engineer for the same company, both graudates of the Agricultural College, took active interest in the work, expended time, furnished transportation, and Mr. Preston was instrumental in putting the facilities of the canal at our disposal. Hon. A. E. Bent and Thos. Berry, of Lamar, president of the Lamar Canals, and engineer in charge of the Amity Canal, E. C. Hawkins, chief engineer of the latter system, also aided by helping in the seepage measurements, in the sediment observations, in attempting to determine the losses from a long stretch of canal and in many other ways. Likewise Hon. W. M. Wiley, of Holly, the general manager of the Amity and other canal systems, placed every facility at our disposal, arranged in many ways to facilitate the work and to render it possible. W. F. Crowley, of Holly, placed his fruit farm at our service, constructed weirs and maintained the observations on the water used. W. F. Montgomery, connected with The Great Plains Storage Company, also aided, as did numerous others connected with the company.

Mr. H. O. Brown, a graduate of the College living at Salida, took an interest in the sediment observations and began their collecting.

In the San Luis Valley, M. D. Blakey, of Monte Vista, Water Commissioner of district No. 20, helped in the seepage measurements on the Rio Grande. A number of others helped in various ways, as M. B. Colt, at Alamosa; W. R. Hapney, of Alamosa, with information concerning artesian wells, and observations on their pressures.

Hon. L. H. Dickson, of Longmont, Water Commissioner of district No. 5, aided for several days in the measurement of the seepage on St. Vrain creek.

J. H. McClelland and W. M. Post permitted their farms to continue to be used as a field of experiment, and Mr. McClelland actively aided in the collection of the data desired.

Mrs. F. W. Sherwood, of Glen Eyre; Geo. Barnes, of Pinkhapton; Carlyle Lamb, of Estes Park; P. H. Boothroyd, of Arkins; C. B. Andrews, of Home P. O. and Fort Collins, all aided materially as volunteer observers, as did John Deaver, of Home P. O.

Mr. Enos A. Mills, of Estes Park, took a special trip to the top of Long's Peak, at an elevation of nearly 14,300 feet, in order to make simultaneous actinometric observations in connection with myself, who took observations at 9,000 feet.

Also to Messrs. Frank Trumbull and Henry Michelsen, of the Union Pacific, Denver and Gulf railway, and to Messrs. Paul Morton, vice president, and J. E. Frost, land commissioner of the Atchison, Topeka and Santa Fe railway, for important courtesies, without which the work of the summer could not have been carried on.

Our thanks are due to all of these, besides many others who have aided in a lesser degree. The assistance has been freely rendered, and has served to stretch the possibilities of the funds placed at our disposal.

Nor should many of the press of the State be omitted from the list. Their support has materially aided

the work. I would especially mention the Fort Collins Courier for its gratuitous publication of the weekly river bulletins, and the furnishing enough slips to send to the ditch men and papers of Northern Colorado.

Thanking the Committee for their active support, this report is respectfully submitted.

L. G. CARPENTER,
Meteorologist and Irrigation Engineer.

December 14, 1898.

Report of the Rainbelt Experiment Station.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—I herewith present the Fifth Annual Report of the Rainbelt Experiment Station.

The season of 1898 was the shortest in the history of the Station. Snow fell May 1st, accompanied by a severe storm which did considerable damage to young cattle on the range. Then a severe snowstorm occurred September 10th.

Planting was delayed on account of the ground being too wet to work during the first ten days of May. The season continued to be favorable for crops until towards the last of July, when dry weather at critical periods cut down the yields of many very promising crops.

The following table shows the precipitation at this Station from the time record-keeping began until the present:—

	1894.	1895.	1896.	1897.	1898.	Means.
January	...	.67	.45	.26	.03	.35
February	...	.27	Tr.	.10	.00	.09
March	...	.16	.71	1.58	.61	.77
April	...	1.67	3.41	1.20	2.20	2.12
May	...	1.46	2.28	1.44	5.54	2.68
June	.48	2.69	3.03	2.22	3.95	2.47
July	1.99	6.38	2.27	4.19	2.09	3.38

	1894.	1895.	1896.	1897.	1898.	Means.
August	1.03	1.22	3.07	3.24	1.33	1.98
September	.14	Tr.	.84	.92	2.00	.78
October	.14	.21	.78	2.73	....	.96
November	.00	.30	.00	.10	...	.10
December	.55	.42	.60	.20	...	.44

The crops were planted according to the schedule. All crops on the special schedule were cultivated carefully as in past years, but the south half of the cultivated land was planted to sorghum and millet and allowed to produce what it would without further attention. Light crops of fodder were cut from the south half of the field; but that which received special care yielded fair crops ot forage.

The small grain was all cut when in the dough stage, except small plats which were left to mature seed for the purpose of estimating the yields. According to the schedule, all small grain was to be planted by the "Campbell Method," so all planting was delayed until after the sub-surface packer arrived, April 25th.

HORTICULTURE.

All forest trees have made a good growth this year. The wind-break around the orchard, composed of ash, black locust, and Russian mulberry, now affords considerable protection. In the spring of 1897, seeds of black locust, black cherry, red mulberry, Russian mulberry, and box-elder were planted. None germinated last season except the black locust, and the seedlings from these are now five feet high. The box-elder and black cherry seeds came up this season, and the seedlings are about a foot high.

All fruit trees have grown well. None has died since the last report.

The standard cherry trees bore some fruit this year. The Rocky Mountain cherry trees were loaded, as usual, with fruit, which, for all ordinary purposes, is worth-

less. The plum trees bore a small quantity of fine fruit. The gooseberry bushes bore a heavy crop of extra fine fruit. Two Missouri Pippin apple trees blossomed, but dropped their fruit before it matured.

Two dozen seedling peach trees have been grown this year from pits planted here. They appear to be quite healthy.

THE GARDEN.

Good yields of various garden crops were produced. Salzer's tree bean yielded especially well. It seems to be the bean to plant here instead of the Navy bean, which does poorly in this region.

The melons, squashes, cucumbers, and pumpkins were planted just before a heavy rain. The rain packed the ground so hard that but few of the plants came up, and these did not grow well. A few melons of good quality were produced.

Fifteen varieties of sweet corn were planted May 18th. From these, roasting ears were used from July 26th until September 25th. The best varieties this year proved to be Maule's First of All, Black Mexican, Early Bonanza, Nonesuch, New Champion, Country Gentleman, and Egyptian. These came into roasting ear in the order named. All these varieties produce ears which are long enough so that a worm can live happily and eat all he needs, while there will still be a good-sized roasting ear left for the table.

Queen's Golden and White Pearl pop corn made good crops.

Parsley, anise, sage, and upland cress were added to the list of garden crops which do well in this region.

Irish potatoes were a poor crop here this year. The earliest varieties got a good start before the beetles attacked them, and made a fair crop. The Early Six-weeks, Early Ohio, and Early Montana made the best yields. The late varieties were so damaged by the beetles that we may call them total failures. The vines

were kept covered liberally with Paris green from the time the beetles began to come until late in the season. But as soon as one horde of beetles would eat and die, another moved in to commit suicide in the same way, until the vines were completely defoliated and some of the stems eaten into the ground.

I furnished a small quantity of seed potatoes to a neighboring ranchman. His were early sorts, and were planted the first week in June. He reports a yield of 60 bushels per acre.

FIELD CROPS.

California Barley—Two acres were sown broadcast upon corn stubble, April 30th, and disced in. All except a small plat was cut for hay. The test plat showed a yield of 18 bushels per acre.

Bromus inermis—Two acres were sown to bromus inermis, April 30th, on deep-plowed ground, a part of which was packed with a Campbell sub-surface packer. A good stand was obtained. Some on high land died during a dry time in the summer, but there is still enough left to make a fair test of the value of the plant for hay.

Alfalfa—One-half acre of alfalfa was sown in May 1897. This was cut in June of this year, making a yield of a ton per acre. It did not grow high enough to cut again during the season.

Other Forage Plants—Eight varieties of non-saccharine sorghum, four varieties of cow peas, one of Canada field peas, and one of Idaho peas were planted on ground plowed eight inches deep and packed. All these were carefully cultivated.

The following table shows the yields:—

Kaffir corn No. 39, 12 bushels seed per acre.
Brown Duhra, 20 bushels seed per acre.
Jerusalem corn, 15 bushels seed per acre.
Red Kaffir corn, 5,320 pounds of fodder.
White Kaffir corn, 6,720 pounds of fodder.

Black-hulled White Kaffir corn, 6,565 pounds of fodder.

Black Rice corn, 4,970 pounds of fodder.

Yellow Milo-maize, 5,110 pounds of fodder.

Kansas Orange sorghum, 8,400 pounds of fodder.

Early Amber sorghum, 6,192 pounds of fodder.

Black-eyed cow peas, 6 bushels of seed.

Black cow peas, 1.5 bushels of seed.

Whip-poor-will cow peas, only a few pods matured.

Clay cow peas, only a few pods matured.

Idaho peas, 11 bushels of seed.

Canada field peas, 8.5 bushels of seed.

Red Kaffir corn, White Kaffir corn, and Kansas Orange sorghum failed to mature seed. Yellow Milo-maize, Black Rice corn, and Early Amber cane produced some mature seed.

THE USE OF GYPSUM.

A plat extending across a patch of land which had never yet produced a crop on account of some unknown qualities it possessed, was treated with gypsum at the rate of one thousand pounds per acre. This plat and another adjoining one were planted to Early Amber cane the same day. The cane was planted in rows with a planter drill. Both plats were cultivated alike. The crops growing on the two were cut the same day. After curing, it was found that the treated plat yielded 2,880 pounds of fodder per acre, while the untreated yielded but 1,620 pounds of fodder per acre, making a difference of 1,260 pounds of fodder per acre which seems to be due to the use of gypsum. In harvesting the crop, the barren spot could hardly be noticed on the treated plat.

MIXING CORN.

In this region, where hot winds are likely to blow at critical times, the corn crop is frequently an entire failure on account of a day of hot winds. The hot winds,

coming when the tassels are in blossom, kill all the pollen and thus leave the seeds unfertilized. If only one variety of corn is planted in a field and all is in tassel when a hot wind blows one afternoon, it will produce but a few ears. But, if a number of varieties which blossom a few days apart are planted, some tassels will escape the hot wind and live to fertilize many ears, thereby increasing the yield considerably. With this in mind, we made three mixtures for planting this year. The seed was chosen from the crop grown here in 1897. Six varieties of white dent were mixed for white dent. Eight varieties of yellow dent, and twelve varieties of flint were mixed to plant for flint corn. These mixtures were planted in separate plats. Each was thinned to two stalks in a hill, and all suckers were pulled off. After it tasseled, all stalks which had no ears started were de-tasseled so that no barren stalk could reproduce its kind. The corn grew well, but as no hot winds occurred during the blossoming period, we can not say that any gain resulted from the mixing of varieties. We shall choose the best matured ears from the strongest stalks for next year's seed, and hope to get a number of cross-bred ears for future use.

We have found that varieties of corn do better here after they are acclimated. So, we hope to produce a few "natives" by the process above described. It is a haphazard way of crossing, but is just what any farmer can do for himself and what most farmers have done either accidentally or purposely. We believe that the idea should be more used in this region, where our climatic conditions make it necessary.

VARIETIES OF CORN.

Twenty-two varieties of corn were planted. The following table gives the yields of the different varieties:—

	Variety.	Kind.	Bushels per acre.
1	Mercer	Flint	14.0
2	Houghton's Silver White	Flint	13.1
3	Sanford's Early	Flint	14.6
4	Waushakum (yel.)	Flint	8.6
5	King Philip	Flint	13.4
6	Squaw	Flint	12.3
7	N. D. Flint	Flint	13.0
8	S. D. Flint	Flint	8.6
9	Golden Row (yel.)	Dent	15.4
10	Angel of Midnight	Flint	8.6
11	New Leaming (yel.)	Dent	10.8
12	Star Leaming (yel.)	Dent	11.7
13	Parson's White	White flint	16.0
14	Murdoch's 90-day (yel.)	Dent	10.0
15	Early Yellow Rose (yel.)	Dent	8.6
16	Dakota Dent (yel.)	Dent	10.8
17	Queen of the Field	Yellow dent	12.3
18	Queen of the North	Yellow dent	13.1
19	Early Huron	Yellow dent	4.5
20	Canadian Yellow	Yellow dent	9.6
21	White Cap Yellow Dent	White dent	12.6
22	Swadley White	White dent	13.1

According to the experience of this Station, and also of the settlers here, the most reliable varieties of corn for this region are those which mature in from 90 to 100 days from planting.

THE CAMPBELL METHOD OF SOIL CULTURE.

What is commonly called "The Campbell Method of Soil Culture" has been so extensively advertised, and so much has been claimed for it, that it was thought best to give it a careful trial at this Station.

Mr. B. A. McAllaster, of the Land Department of the Union Pacific System, kindly loaned us tools for this purpose.

The ground for small grain was plowed and packed April 25th to 27th, and the grain was drilled immediately with a press drill across packed and unpacked ground. A part of the grain was cultivated after rains with a Campbell Jr. cultivator. All except enough to test the yield was cut for hay. The following table shows the results given in bushels per acre:—

	Packed.		Unpacked.	
	Culti-vated.	Uncul-tivated	Culti-vated	Unculti-vated.
Wheat, Blount's No. 16........	3.50	3.75	4.75	4.50
Oats, Black Russian...........	18.00	23.00	30.00	27.00
Rye, Giant Spring..............	5.25	5.00	5.15	4.10
Barley, Beardless...............	22.6	20.60	25.70	14.60

Early Amber Cane—One and one-half acres were planted to Early Amber cane May 25th. All the land was plowed eight inches deep and three-fourths of it was packed. The seed was planted with a planter drill. The cane was all carefully cultivated until August.

The cane on the packed ground yielded 6,444 pounds of dry fodder per acre, while that on the unpacked ground yielded 5,940 pounds per acre, a difference of 504 pounds for packing.

CORN.

Four acres were planted May 21st to corn. The same method was used in preparing the corn land as in the case of the sorghum plats. The corn was planted in check rows, by hand, three grains in a hill. The seed was Yellow Dent, White Dent, and Flint, grown at this Station in 1897. It was chosen from the best of six varieties grown. All was carefully cultivated after each rain and more frequently when conditions seemed to require it. The suckers were pulled off, and all weak stalks were removed after they had shown their form. It was also thinned to two stalks in each hill. The following table shows the results:—

Variety.	Packed. Bu. per acre.	Unpacked. Bu. per acre.	Differences. Bu. per acre.
White Dent................	10.5	10.9	.4 Loss
Yellow Dent...............	13.4	8.7	4.7 Gain
Flint	14.3	12.6	1.7 Gain

Potatoes—One-fourth of an acre was planted to Carman No. 3 potatoes, May 13th. One-half the ground was packed and one-half left unpacked. The potato beetles committed such depredations in this section of the field that only a few tubers were produced.

REMARKS.

1. All ground in this test was plowed eight inches deep.

2. All ground not packed was thoroughly harrowed as soon as it was plowed.

3. All crops in this test which are usually cultivated were cultivated alike on both packed and unpacked land.

4. The moisture in the soil was tested a few times during the season by sampling with soil sampling tubes to a depth of one foot, and to the depth of six feet with a sampling auger. It was found that immediately after a rain, the upper foot of the unpacked plats contained more moisture than the upper foot of the packed plats. Later, the reverse was the case. Also, the moisture falling upon the unpacked plats sank deeper into the ground than that falling upon the packed plats. Later in the season, after several rains had fallen and all plats had been cultivated several times, the differences were not so noticeable.

We give no figures here because we had not the time to make as many moisture determinations as we wished, but could go over the ground only in a general way. It is possible that with more work in this line, we should be forced to draw different conclusions.

STUDY OF EVAPORATION.

Tools for use in these experiments were ordered April 15th, but many delays caused by non-arrival of essential tools and inability to get help when needed, prevented work in this line before July 1st.

We had planned to determine the amount of water used by a crop of corn in this region, but it was considered too late to give this matter a fair test by the time the necessary tools were at hand, so evaporation from water and soil surfaces was tested during the remainder of the season.

EVAPORATION FROM WATER SURFACE.

Two galvanized iron cans eighteen inches in diameter and fifty-two inches deep were set close together in the ground so that the tops of the cans were on a level with the surface. These were filled with water. During July, the evaporation was 11.38 inches. Both were exposed equally to the action of the sun and wind during this time. August 1st, one was screened from the direct rays of the sun and the other was left uncovered. From August 1st until September 24th, the one in the shade lost 14.75 inches while the one in the uncovered can lost 18.43 inches.

The can which was uncovered was left until October 3d, when it was found that it had lost 35.31 inches during the time from July 1st until October 3d, or 95 days.

EVAPORATION FROM DIFFERENT TYPES OF SOIL.

In this test four types of soil were used. No. 1 is a soil very common here on level upland. It is of a mulatto color, containing a small per cent. of clay, considerable sand, and enough lime to cement it so that it is quite hard when in its natural condition.

No . 2 is a type found on a hilltop. It is a very fine black soil upon which very little vegetation has grown since the Station has been in operation.

No. 3 is a rich clayey soil of a dark color, upon which all crops grow well whenever the location is such that the crops are supplied with water in moderate quantities. The best crops grown on the farm grow upon this type of soil.

No. 4 is a fine light-colored soil commonly called "gopher clay." Where it crops out, it supports quite a scanty vegetation, as a rule. It occurs in many places as a subsoil.

One can, eighteen inches in diameter and fifty-two inches deep, was used for each kind of soil. The cans were filled as the soils occur in nature. Subsoils occupied the lower parts of the cans, but the upper eight inches were filled with the types to be tested. All cans were placed side by side in a trench so that their tops were on a level with the surface of the ground. They were weighed at the beginning of the experiment and at intervals through the summer. Water was added from time to time to all the cans at the same time. The water was introduced through a piece of gas pipe which extended two and one-half feet below the surface. In this way water equal to three inches of rainfall was added to each can of soil, besides the natural rainfall. Nothing was allowed to grow on any of the soils. After standing 85 days, the amount of loss was estimated. It was found that type No. 1 had lost water at the rate of 1,038 tons per acre; type No. 2 at the rate of 527 tons per acre; type No. 3 at the rate of 435 tons per acre; and type No. 4 at the rate of 600 tons per acre. None of this soil was cultivated. Four other cans just like the ones described were filled with subsoil and soil of type No. 1. In two of these, millet was planted, while two of them were left bare. After 85 days it was found that the average loss from the bare soils was 905 tons per acre, while the average loss of the two upon which millet was growing was 1,056 tons per acre. The millet grew to be only four to six inches high before it formed heads. Three inches of water besides the rainfall was added to each of these cans also.

Another test of evaporation from soil surface was in connection with a wind-break test. Twenty galvanized iron buckets, each eleven and one-half inches in diameter, were all filled to the same level with the same kind of soil and sunk into the ground so that their tops were on a level with the surface. Ten of them were in buffalo grass sod and ten in a millet field. Their positions represented a sufficient variety of exposure and protection to make a fair test, and to consider that they would represent average conditions on the farm for that type of soil. Type No. 1 of the soil was used, as representing the widest area of any of the soil types found here.

The buckets were left in position sixty days. Water was added to each bucket occasionally by means of glass tubes which reached nearly to the bottom of the buckets. In sixty days, beginning July 13th and ending September 13th, the average loss of water per acre from the soil in the buckets was 705 tons. Nothing was allowed to grow in the soil in the buckets. The soil was left unstirred.

INFLUENCE OF A WIND-BREAK UPON EVAPORATION FROM SOIL SURFACE.

In 1896, twelve rods of sod wall were built east and west across a field of buffalo grass which sloped to the south. In 1897, this wall was extended eight rods by building a tight board fence. All the wall and fence was made four feet high. Buckets were placed in the ground on each side of the wall. All the buckets were filled alike with the same type of soil. On the north side, the buckets were placed at one, three, five, seven, and ten rods distance from the wall. On the south side, they were placed one, three, five, seven, and eight rods distant. The table below shows the results of evaporation from the pairs of buckets during 62 days, from July 14th to September 14th.

North side of Wall, in sod.	Evaporation—tons per acre.
Buckets one rod from wall	677
Buckets three rods from wall	633
Buckets five rods from wall	700
Buckets seven rods from wall	703
Buckets ten rods from wall	712
South of wall in millet field.	
Buckets one rod from wall	647
Buckets three rods from wall	686
Buckets five rods from wall	738
Buckets seven rods from wall	764
Buckets eight rods from wall	761

Some negative results are apparent here, but the general results show that the wind-break did save moisture. We do not feel able to explain the differences which appear. As an experiment to test the influence of wind-breaks upon evaporation, we consider it very unsatisfactory, but for testing evaporation from soil surface, it shows some interesting figures. The location of the buckets was such that their weights could be but little, if any, affected by the blowing of dust which had been considered as the greatest source of probable errors in this test.

ADDITIONS TO TOOLS AND APPARATUS.

A Campbell sub-surface packer and a Campbell Jr. cultivator were furnished the Station by the Union Pacific System for use as long as ten acres of the station land are devoted to testing the "Campbell Method of Soil Culture."

Ten galvanized iron cylinders, 18 inches in diameter and 52 inches deep, for use in testing evaporation and also in testing the amount of water used by plants, three dozen galvanized iron buckets for general use in soil work, one evaporating oven, four dozen evaporating

dishes, twenty feet of special copper tubing, thirty-five soil-sampling tubes, and one special weighmaster's beam have been added to the apparatus for the study of soils and other problems.

CONCLUSIONS.

The Station has been in operation five seasons, and during that time no grain crop has been produced which would pay if the producer had to depend upon the sale of it for his living. Fair crops of fodder have been raised each year since the first, when the seed was planted on sod. That year was an extremely dry year, but enough fodder was raised then to feed the station stock until the next season's crop was ready for use.

No fair test of fall grain has yet been made. Fall grain was sown but one year on the Station soil. Some good crops of fall wheat have been raised in this county.

The cost of producing fodder is the most important question to be considered in this region. It is believed, from our experience here, that fodder can be produced, on a large scale, at a cost of not to exceed two dollars per ton. The figures below show the estimated cost per acre of growing fodder.

Preparation of ground and planting	$1.00	
Seed	.10	
Cultivating three times	1.20	
Cutting and putting in shock	1.00	
Total		$3.30

The yield of the Kaffir corns and of Early Amber cane is usually between one and one-half and five tons per acre. If improved harvesting machinery be used, we believe that the cost of putting fodder in the shock would be still less than the above estimate, which is based upon the use of sled cutters in harvesting the fodder.

ACKNOWLEDGMENTS.

Members of The State Board of Agriculture have greatly assisted me by their sympathy with my efforts to make the most of conditions here. I have also been helped very much by suggestions from members of your Committee.

Respectfully submitted,

J. E. PAYNE,

Superintendent.

Cheyenne Wells, Colorado, October 15, 1898.

Report of the Arkansas Valley Experiment Station.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—Herewith is presented the Eleventh Annual Report of the Arkansas Valley Experiment Station.

My connection with this Station dates from March 1, 1898, at which time the schedule of the season's work had been adopted: hence the most of my duties have been to carry out the line of work laid down therein, as far as conditions would permit.

The present year has been an unfortunate one for the agricultural interests of a large portion of the Valley, including the Station.

On the 6th day of June, a severe hailstorm devastated this section, and for the time being thrifty crops were transformed to a bare waste.

Nor was the destruction of the crops the only severe feature of the storm affecting subsequent agricultural operations, as is evidenced by the poor mechanical condition of the soil induced by the severe flooding.

For nearly eight hours most of the station land was under water to a depth of about eight inches, the effect being thoroughly to compact what was previously a loose, mellow soil, which conditions could not be overcome by surface cultivation.

The season, in general, has been characterized by an excess of rain and by moist conditions, causing heavy

dews. An unusual amount of fungous diseases has been prevalent.

During the storm referred to, 2.08 inches of rain and hail fell in two and one-half hours.

Subsequent to this, and of results almost as disastrous as the previous one (except no hail), was the storm of July 8th, when 1.5 inches of rain fell in a few hours; sufficient again to place the station land under a considerable depth of water.

An excess of water is very detrimental to the soils of this Valley, especially so if allowed to stand. Better results would often be obtained by more cultivation and less irrigation.

AGRICULTURAL DIVISION.

Wheat—The wheats grown for a comparative test were destroyed by the hail of June 6th, at which time they were well headed.

The last week of September 1898, twenty-one varieties, including some Russian wheats, were sown on 2.8 acres of land.

March 17th, 350 pounds of Polish wheat, or Mammoth rye, were sown on 3.7 acres of land. This seed came up nicely without irrigation, and the crop was looking well at the time of the hail, just as the heads were forming.

All the main stalks were destroyed; the tillers afterwards grew and produced 35 bushels of grain.

We consider this grain a valuable one that promises to enter largely into feeding rations. It produces well with but little water, and is especially valuable for lands under canals with scant water supply.

Corn—Test on culture; cultivation *versus* irrigation. The schedule called for nine acres to be laid off into plots of one acre each and treated as given in Table I.

TABLE I.

No. of plot	No. of cultivations.	No. of irrigations.
1	3	3
2	3	2
3	3	1
4	2	3
5	2	2
6	2	1
7	1	3
8	1	2
9	1	1

Table II. gives the dates of cultivation and irrigation, together with the yield.

TABLE II.

No. of plot.	Yield in pounds.	Dates of cultivation.	Dates of irrigation.
1	1,775	July 6 and 12, Aug. 4	July 22, Aug. 8 and 23
2	2,010	July 6 and 13, Aug. 4	July 22, Aug. 9
3	2,005	July 6 and 13, Aug. 4	July 30
4	2,120	July 7 and 12	July 23, Aug. 8 and 23
5	2,115	July 7 and 13	July 23, Aug. 9
6	1,695	July 7 and 13	July 30
7	2,395	July 12	July 27, Aug. 8 and 24
8	2,215	July 12	July 27, Aug. 9
9	1,685	July 12	July 29

This land was planted to Golden Beauty corn on May 14th, and at the time of the hail was up, in good stand, about four inches high. The storm reduced the stand considerably by covering some hills with mud.

The whole crop had received the same attention up to July 6th; viz., one cultivation with shovel plow to kill small weeds, and after the hail the use of an Acme plow to stir the soil. Some hogs running at large de-

voured a considerable quantity of corn on Plat 1, and for this reason this plat must be eliminated in drawing any conclusions.

The fertility of this soil was not uniform, as we afterwards learned; cattle having been fed upon plats 7 and 8 the previous winter.

In general it may be said, that corn should seldom be irrigated until near the time of tasseling; after which one more irrigation will be sufficient to produce the crop.

Corn on alfalfa sod—This is the third year corn has been grown continuously on this land (4 acres) for the purpose of testing how long the fertility of alfalfa will remain.

One and one-half acres near by were planted at the same time as a check upon this work. The first mentioned produced 8,470 pounds of ear corn, equivalent to 30.2 bushels per acre, of 70 pounds each.

The latter portion produced 3,535 pounds of ear corn, or 33.6 bushels per acre.

The appearance of the corn during growth showed very plainly that the fertility from the alfalfa had been exhausted. The unhealthy, yellow appearance showed that the supply of nitrogen was not sufficient for a maximum crop. On the check portion (a soil naturally much weaker), the growth was rank and of a dark healthy green.

Grasses and Forage crops—Under this head, as outlined in the schedule, the following were sown:—

Turkestan alfalfa, Italian Rye grass, Brome grass (*Bromus inermis*), Tall Meadow Oat grass, Kentucky Blue grass, Sheeps' Fescue, Meadow Fescue, Idaho coffee pea, Mummy field pea, Southern cow pea, Soja bean, Rape, and Hairy Vetch.

The alfalfa and brome were sown April 14th and a good stand secured, but the hail beat them to the ground so severely that the weeds took the start and choked them out.

The alfalfa was sown September 9th, and promises to do well.

The rye grass and fescues are also a failure, due to hail and weeds.

The meadow grass was not sown until June 28th, and promises to be of value.

Some are growing the Kentucky blue grass for pasture. It can not be utilized for this purpose except where water is abundant. We are of the opinion that fall is the preferable time to sow this grass, as the weeds do not then become so troublesome.

The Idaho and field peas were severely injured by the hail. Of the former, we threshed 300 pounds, or nearly 14 bushels per acre. It is probable that under normal conditions 30 bushels per acre can be grown.

Early field peas might be grown to a profit. As a food for young hogs during the summer months, when growth and not fat is desired, they are excellent.

The hail required us to replant the cow pea and soja bean. The former ripened but few seeds; only the earliest varieties will be productive here. We think it a plant of much value, both for its grain and as a fertilizer for small tracts.

The Hairy Vetch—This we wish to test both for its value as a forage plant and green fertilizer. Two sowings were made, May 23d and again in July. Early sowing of this plant is not desirable as but little growth is made during the hot weather. Further time is necessary to determine its value.

Essex Rape—An early planting was destroyed by the flea beetle.

A second planting, August 3d, made a growth of 12 to 16 inches, but we do not consider it a desirable plant here.

Since the Station has been in operation, tests have been made of most of the more common grass and forage plants. But three were growing when I assumed charge, *Bromus inermis*, orchard grass, and red clover. A test of the first for the past six years has not established it as a pasture grass for this section. It commences to grow quite early in March but in summer does but little, again

making some growth in the fall. We think in sections of greater rainfall and lower mean temperature it would prove valuable. However, to test it still further, a fall sowing has been made and is doing well.

From our present knowledge we consider orchard grass the best one for pasture purposes. It thrives either alone or in connection with alfalfa. At the time of the hail it stood from 2½ to 3 feet high. It resists drouth well, and for pasture or to improve the quality of alfalfa it can be advantageously used.

GARDEN.

Celery—Three varieties of celery were grown, White Plume, Golden Self Blanching, and Boston Market.

This plant requires a moist, cool, loamy soil made very rich by heavy manuring.

Our trials have shown the following particulars must be observed:—

Run off quite deep furrows east and west and place the plant on the south side of them to insure partial shade. None but the strongest plants should be used, as the smallest will not survive the heat.

For a time, after transplanting, almost constant irrigation must be given. Of the two early varieties we much prefer the White Plume for its richer and better flavor.

The only method of blanching used was with earth. More extended notes are reserved for the future.

Potatoes—Our trials comprised five varieties, Burbank, Barclay's Prolific, Rose Seedling, Prolific Rose, and Mammoth Pearl.

On a half acre plat, May 2d, twelve rows, each 100 feet long, were planted to the Rose Seedling variety to compare the time of planting with that of a later date. May 25th, the remainder of the half acre was planted to the above varieties; twenty rows being of the Rose Seedling.

To five rows of this variety wood ashes were applied in the furrow. A top dressing of 150 pounds of gypsum was applied to six rows June 28th.

The following table gives the area and yield of the different varieties; no mention being made of those too small for seed purposes.

Variety.	No. of rows each 100 feet.	Total yield in pounds.	Yield per acre in bushels. Estimated.
Rose Seedling	9	116	31.1
Burbank	7	400	138.0
Barclay's Prolific	7	275	94.8
Mammoth Pearl	8	300	90.5
Rose Prolific	8	315	95.0

From the five rows treated with ash we secured 40 pounds, from those treated with gypsum 90 pounds, and from the twelve rows planted May 2d, 98 pounds. Our experience, as well as the tests of former years, has shown that the early plantings are not successful nor are early maturing varieties as productive as the late maturing ones; that to insure success late blooming varieties and late planting are essential.

As a further test six rows each (100 feet long), were planted of the Burbank and Rose Seedling varieties and covered with straw to a depth of eight inches.

The former yielded 182 pounds and the latter 72 pounds. There is no advantage in this method; the potato requiring cultivation to secure best returns.

A difference in the mechanical condition of the soil was noticeable where gypsum had been applied; its tendency being to make it more mellow and friable.

The soil and climate here do not favor the potato, but we see no reason why by judicious planting and irrigation the farmer should not supply his own needs.

Of the varieties tested we much prefer the Mammoth Pearl on account of its smooth growth and uniform size.

Sugar-beets—One-half acre of beets was grown, under instructions from the Agricultural Section of the

College, to derive information in regard to the follow ing:—

(a) The best time to plant.
(b) The proper depth to plant.
(c) The quality of water required.
(d) Irrigation *versus* natural moisture for the germination of the seed.

Four plantings were made, April 18th, May 2d, May 16th, and June 1st.

The plants from all sowings (except June 1st), were up at the time of the hail and were greatly injured by it. The rainfall this year has been sufficient to grow good beets. From a plat planted to the Vilmorin variety, and irrigated four times, 1,300 pounds were harvested; from the same amount of land without irrigation, 1,315 pounds; and from the plat receiving one irrigation, 1,365 pounds. Our work shows that 18 inches between the rows is not sufficient where irrigation is employed; that two feet is close enough, and where the product is designed for stock use a still wider distance is preferable.

The half acre produced a total yield of 7 tons and 855 pounds.

As the work with the sugar-beet will probably appear in bulletin form, further details will not be entered into in this report.

HORTICULTURAL DIVISION.

Orchards—Twenty-nine varieties of apples, in the old orchard, put forth bloom from the 24th to the 30th of April.

The hail destroyed all of the first set except those of the Ben Davis variety, which were afterwards used in taking notes upon the codling moth. But two varieties of pears remain in the orchard (Keiffer and Longworth), which blighted in the bloom.

The work with the blight has comprised; first, spraying with the Woodbury Blight Cure and with the Bordeaux mixture; second, to determine to what extent the

blight may be carried to healthy trees in the operation of pruning and to note the efficacy of a germicide upon the implements employed.

In the spraying experiments, trees were left in such localities as carefully to check our work, and the results of this year show that no benefit is derived from either of the mixtures used.

The directions for applying the former, together with the Woodbury wash, were strictly adhered to, and had the farmers of this vicinity been content to allow the Station to test it before they purchased, hundreds of dollars might have been saved to them this year.

All vacancies in the young orchard were filled with the same varieties as formerly set, as far as they could be obtained.

Nearly all these trees had commenced a good growth when the hail of June 6th stripped them of their bark from the ground to the top of the tree.

The stone fruits repair the damage done by such storms much more rapidly than do apples or pears.

There are in this orchard at present 119 trees, comprising apple, peach, plum, cherry, quince, apricot, and nut that appear to have survived the storm sufficiently to remain.

Of the elm trees set along 80 rods bordering the avenue, all but one are living.

INSECTS AND FUNGOUS DISEASES

Experiments to ascertain the per cent. of wormy to non-wormy apples were conducted upon eleven Ben Davis apple trees.

The same trees were also used to determine the number of worms going down the tree compared to those going up.

The results of the work have been reported to Professor Gillette, and further investigations along this line are contemplated.

The Striped Cucumber beetle, which is very destructive to the cantaloupe plant, first appeared (in increased numbers) during the last week of May. Experiments as to the best means to combat this insect were conducted but were not completed owing to the destruction of the plants by the hail.

The remedies used were Paris green, tobacco water, kerosene emulsion sprays, and dusting with a mixture of lime and Paris green.

The emulsion is the only effective remedy of those above mentioned. Dusting the plants with lime and Paris green answers for a short time, but the beetles may soon return.

Notes were taken upon the Strawberry Leaf-roller, and upon an adjoining patch we are studying the efficacy of burning the vines in the fall to rid them of this insect.

The 8-Spotted Forester, which eats the leaves of the grape in May, is successfully combatted with a Paris green spray (10 oz. to 10 gallons of water).

A poison spray is effective for the Yellow-Necked caterpillar, which destroys the foliage of the apple.

Cottonwood-leaf beetles appeared in abundance upon the trees belonging to the poplar family. A poison spray may be used to combat them.

The Melon louse appeared upon the cantaloupe vines in a few localities. It is important that this insect should be at once exterminated to avert serious injury to an important industry. Some information to this end was given our farmers by means of the local press.

A fungous disease affecting the cantaloupe has proven quite serious in a few localities.

In conjunction with Professor Crandall, we are investigating the subject, and experiments to control it may be entered into another year.

The bean blight has proven quite serious and suggests future study.

Mildew was more troublesome than usual on account of an unusually moist season.

METEOROLOGY.

Records of temperature, hygrometer, precipitation, wind, clouds, and sunshine have been kept and reports sent monthly to the Department of the College and to the Weather Bureau in Denver.

FERTILIZERS.

Decomposed gypsum and wood ashes constitute the fertilizers employed for experimental purposes.

Upon 124 square rods of land, that had previously received so much water as to destroy its productiveness, gypsum was applied to alternate plats. This land had been plowed in the fall and coarse manure spread upon it during the winter. In the spring the soil appeared quite mellow and apparently the freezing and thawing had put it in proper condition for crops. It was again plowed this spring and corn and beans (which are widely different in character) selected as the crops to be grown upon it.

Upon one-half (43 square rods) the area planted to beans, 375 pounds of gypsum were applied as a top dressing. The blight seriously affected them and a yield of 156 pounds was secured from the plat receiving gypsum, while that receiving no application returned 150 pounds. Three plantings were required to secure a stand of corn upon this soil; there seemed to be some condition not favoring germination. The stand that was secured was late, making an excellent growth of stalk but not thoroughly maturing the grain.

From 18.7 square rods receiving gypsum 276 pounds of ear corn was obtained; from the same area, but no application, 178 pounds were taken. Brome grass was not benefited by an application of gypsum. We also applied it to trees, but time is needed to determine results. Our work with gypsum this year was not intended to be more than preliminary.

While we do not look for any *decided* benefits from its application to soils similar to those of the Station, yet there is much land in this Valley that would be greatly benefited by its use, as we know from former trials with it under similar conditions.

FEEDING EXPERIMENTS.

An important line of work was inaugurated this fall when fifteen calves were purchased for experimental feeding.

ALFALFA.

About three acres of land was seeded to alfalfa, September 9th, and at the present writing it is looking well. About 30 tons of alfalfa hay, which will be used for feeding purposes, have been put up.

CONCLUSION.

Many items of importance accumulate, in the course of experimental work, that can not be enumerated in a report like this, but may prove to be of much value in the work of the future.

Respectfully submitted,

H. H. GRIFFIN,
Superintendent.

Rocky Ford, Colorado, November 30, 1898.

Table of Contents.

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J. D. STANNARD, PHOTO.

Fig. 1. FORESTS AND SNOW. Snow Drifts in Green Timber June 21, 1899. Elevation 9500 ft. above sea level. Looking N. E.

J. D. STANNARD, PHOTO.

Fig. 2. Looking Southwest into Dead Timber from same point as Fig. 1 and same date.

The State Agricultural College

OF COLORADO.

The Twelfth Annual Report

—OF—

The Agricultural Experiment Station

For 1899.

Published by the Station,
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1900.

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FORT COLLINS, COLO.

CONTENTS.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

BOARD OF CONTROL:

THE STATE BOARD OF ACRICULTURE.

EXECUTIVE COMMITTEE IN CHARGE.

TO APRIL, 1899.

A. L. Kellogg, Rocky Ford, *Chairman*, P. F. Sharp, Denver,
Alston Ellis, Fort Collins, John J. Ryan, Fort Collins,
B. F. Rockafellow, Canon City.

SINCE APRIL, 1899.

P. F. Sharp, Denver, *Chairman*, B. F. Rockafellow, Canon City,
J. L. Chatfield, Gypsum, Jesse Harris, Fort Collins,
P. A. Amiss, Pruden.

STATION STAFF.

Alston Ellis, A. M., Ph. D., LL. D..Pres. and Director (to Aug. 1899)
B. O. Aylesworth, A. M., LL. D..........................President
L. G. Carpenter, M. S.............Director and Irrigation Engineer
C. S. Crandall, M. S...................Horticulturist and Botanist
C. P. Gillette, M. S..................................Entomologist
W. W. Cooke, B. S, A. M.............................Agriculturist
W. P. Headden, A. M., Ph. D.............................Chemist
A. M. Hawley.......................................Secretary
L. M. Taylor......................................Stenographer
R. E. Trimble, B. S..Assistant Meteorologist and Irrigation Engineer
Frank L. Watrous........................Assistant Agriculturist
L. A. Test, B. M. E., A. C......................Assistant Chemist
E. D. Ball, B. S.........................Assistant Entomologist
C. H. Potter, M. S......................Assistant Horticulturist
F. C. Alford, B. S..............................Assistant Chemist
Joseph Lownes, B. S............................Assistant Chemist
H. H. Griffin, B. S..............................Superintendent
of the Arkansas Valley Sub-station, Rocky Ford.
J. E. Payne, M. S................................Superintendent
of the Plains Sub-station, Cheyenne Wells.

LETTER OF TRANSMITTAL.

To His Excellency, Charles S. Thomas, Governor of Colorado:

I have the honor to transmit, in accordance with the act of Congress establishing Agricultural Experiment Stations, the twelfth annual report of the Agricultural Experiment Station of Colorado. The financial statement is for the fiscal year ending June 30, the other operations being reported substantially for the calendar year.

Respectfully,

L. G. CARPENTER,

Jan. 15, 1900. *Director.*

Secretary's Financial Statement of the Experiment Station Fund, for the Fiscal Year Ending June 30, 1899.

Receipts—	Hatch Fund.	Special Fund.	Total.
United States Treasurer	$15,000 00	....	
Balance on hand July 1, 1899	....	$ 763 66	
Rent, farm, miscellaneous sales	....	1,212 01	
Sheep feeding sales	....	837 76	
Total	$15,000 00	$2,813 43	$17,813 43
Disbursements—			
Salaries	$ 9,082 69	$1,041 63	$10,124 32
Labor	2,246 45	497 28	2,743 73
Publications	1,369 95	205 55	1,575 50
Postage and stationery	48 30	9 70	58 00
Freight and express	48 61	16 40	65 01
Heat, light and water	....	41 05	41 05
Seeds, plants, sundry supplies	251 52	....	251 52
Fertilizers	12 00	144 78	156 78
Feeding stuffs	21 00	2 05	23 05
Tools, implements, machinery	30 25	21 53	51 78
Scientific apparatus	196 97	27 27	224 24
Live stock	668 43	270 00	938 43
Traveling expenses	861 86	122 70	984 56
Contingent expenses	10 00	....	10 00
Buildings and repairs	151 97	21 80	173 77
Total expenditures	$15,000 00	$2,421 74	$17,421 74
Balance on hand July 1, 1899		391 69	391 69
Totals		$2,813 43	$17,813 43

A. M. Hawley,

Secretary of the State Board of Agriculture.

REPORT OF THE DIRECTOR.

To the Executive Committee of The State Board of Agriculture:

Gentlemen—Having assumed the responsibilities of Director on September first, the fiscal year (ending June 30th) covered by this report had already closed. While the reports of the sections are brought to November—a more convenient date for reporting the operations of field work—a large part of the work reported is prior to the term of the present Director.

Since the last published report no change has taken place in the scientific staff of the Station. Mr. J. E. DuBois, who, for four years, had been Secretary of the State Board of Agriculture, and as such came in close contact with the Experiment Station, gave up on account of poor health, and was succeeded by Mr. A. M. Hawley, of Canon City. The pleasant personality of Mr. DuBois made his death, shortly afterwards, seem a personal loss. The termination of the services of Alston Ellis, A. M., Ph. D., LL. D., as President of the Agricultural College, thereby took from the directorship one who was energetic in his management of station interests.

The available time has been largely occupied in the organization of the details of the office, in getting hold of the various threads of the past history of the Station and its branches, and in a study of the financial details as a means of obtaining an insight into the present condition and as a guide for the future. The routine business and correspondence has increased, but it is evident that it may and should become greater as we come in closer contact with the agricultural population of the state. The office of the Director has been

changed from its recent location in the President's office, some new equipment obtained and other ordered.

The change in the organization of the Station and its formation with its own executive head, marks a change in the plan followed for some years back and gives occasion for a more careful consideration of the relation of the Station to the College and its form of organization, in order that the conditions should be most favorable for efficient work.

At the time of the official inspection by the Department of Agriculture, Dr. A. C. True, who has the oversight of the Experiment Stations of the United States, met some members of the Board, and in the course of the conference expressed the result of his experience. He was requested to write the principles which experience had shown to be desirable in the organization and management of Experiment Stations to obtain the best results. This he did in the following letter, which it is desirable to permanently record. The recommendations involve added duties and responsibility on the Director. While it has its undesirable side for the occupant, it also represents the recommendations obtained from the most successful stations represented at the July meeting of the American Association of Agricultural Colleges and Experiment Stations:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., Aug. 19, 1899.

Hon. P. F. Sharp, Denver, Colorado:

DEAR SIR—Referring to our recent conversation regarding the organization and work of the Colorado Experiment Station, it seems to me that the following points should especially engage the attention of the governing Board in considering the reorganization of the Station:

1. The Station is, under the law, a department of the College, and as such, should have an organization which will consolidate it to work as a unit. Experience shows that this can best be done by

giving the Station its own executive head (a director), and organizing a staff to work under his immediate direction.

2. The Director should be made fully responsible for the planning and carrying out of the work of the Station, for its expenditures and publications, and for the management of all business details, and he should be given ample authority for these purposes. The Board should look to him for the initiative in all matters relating to the Station, including the nomination of members of the staff, and should ordinarily confine itself to the appointment of the officers of the Station and passing upon the plans for work and expenditures submitted by the Director, through the president of the College, and auditing accounts. The Director and other chief officers of the Station should be chosen to serve during good behavior and efficiency, and the plans of work and expenditures should be submitted to the Board annually.

3. The members of the staff should be individually responsible to the Director as regards Station work and should be held to the performance of work ordered by the Director, which would often involve the co-operation of several members of the staff. As members of the Station Staff, the professors should be distinctly subordinate to the Director. In this respect they should hold a different position as regards Station work from that which they hold as instructors in the College. Thus the professor of chemistry is the head of the department of chemistry of the College, as far as instruction goes, and, as such, is subordinate only to the president of the College, but as chemist of the Station he should act under the orders of the Director.

4. The Station Council should be simply an advisory body, holding meetings for consultation on Station interests, but voting, if at all, merely to express opinions.

5. The general plan of expenditures should be drawn up annually by the Director, after consultation with members of the staff, and approved by the Board. This should include estimates for salaries, expenses of the several departments, publications, etc. There should always be a certain reserve fund, to be spent at the discretion of the Director, to meet emergencies arising during the year.

Expenditures should be made on requisition drawn by the different members of the staff and approved by the Director, and all bills should be approved before payment by the Director. The accounts and vouchers for each year should be finally audited and endorsed by a committee of the governing Board.

6. The main work of the Station should be along one or two lines, and all members of the staff should co-operate in this work, as far as practicable. This need not exclude smaller pieces of work in

a few other lines, and it is well for each department to have some work in which it is alone concerned. In Colorado it seems natural and desirable that the Station should concentrate its work on irrigation problems, and it should be a leading authority on these problems.

Plans for the work should be carefully drawn up annually by the Director, after consultation with members of the staff and when approved by the Board should be carried out carefully and vigorously. Careful attention should be given to the proper recording of work, and the Station records should be preserved in fire proof safes or vaults.

7. *All* the work of the Station, wherever conducted (whether at Fort Collins or in other localities in the state), should be under the immediate charge of the Director, or such member of the staff as he may assign to have charge, and the Director should be made responsible for the management of all work without regard to locality. Sub-stations are not contemplated by the Hatch Act and have generally proved very expensive and of little value, those in Colorado not being exceptions to the rule.

The Station should work for the general interests of the agriculture of Colorado and should carry on its investigations wherever they can best be prosecuted, but should be free to move its field work from point to point as the requirements of the work may demand. It is not fair to the farmers of the state to maintain expensive sub-stations in two or three favored localities. The amount of field work to be done at Fort Collins should be determined by the nature of the investigations pursued by the Station at any particular time and may be relatively small. If the Station is organized to pursue a series of *special investigations* for the benefit of Colorado agriculture, there will be little difficulty in deciding where the work can best be done. The location of the work in any given instance should, of course, be left to the Director and other expert officers of the Station.

I am not sure I have covered all the points you desired me to touch upon. I shall, of course, be glad to write you further at any time

Very respectfully yours,

A. C. TRUE.

The December meeting of the State Board of Agriculture adopted regulations governing the Experiment Station in accordance with the recommendations of Dr. True.

The work of the Station is by no means confined to the region near the home Station, but has

extended throughout the state, as needs have required. The principal railroads of the state have cordially aided by furnishing transportation over their lines to a greater or less extent. The Santa Fe, the Burlington, the Union Pacific, the Colorado & Southern and the Denver and Rio Grande are all entitled to our grateful acknowledgments for such courtesies to various members of the Station force.

The demands from Colorado, a state with an area as great as New England and New Jersey combined, with climate ranging from Kansas to Spitzbergen, make varied calls on a single Station. The range of questions is greater because the state does not have the experience that becomes common knowledge in old farming localities. Distances are great, trips extending 300 to 500 miles from the College are of almost weekly occurrence. The Entomologist or his assistants has made several trips to Grand Junction, on the Western Slope, to examine the reported ravages of an insect on sugar beets; a collecting trip to the San Luis valley and Gunnison; another through the Arkansas valley, and to Trinidad; one down the South Platte, returning via Cheyenne; one on the plains, and one through the mountains, these latter having as principal objects the study of the grasshopper and an examination into the reported appearance of the destructive Rocky Mountain locust.

The Botanical Section made several trips by rail and by wagon, lasting, in one case, for several weeks, and extending into the high mountains and the Western Slope, in connection with the study of grasses, and for collecting purposes; also into the Arkansas valley, to examine the reported cantaloupe diseases.

The Section of Meteorology and Irrigation Engineering has carried on considerable work in the Arkansas valley, requiring the presence of one or more from the force for a greater part of the

season. Numerous trips have extended as far as the eastern part of the state. The whole 200 miles from the foothills to Kansas have been traversed more than once on wheel and by horse. Numerous series of measurements to determine the amount of water used have been carried on by the co-operation of various public spirited and generous individuals; about 500 miles of measurement to determine the seepage gain of streams taken, etc. Trips have been taken to timber line to observe the effect of forests on the preservation of snow, etc.

The Agriculturist has continued work relating to the sugar beet, and the various co-operative experiments in many parts of the state have caused him to frequently visit widely separated localities.

While the work of the Chemist is principally done in the laboratory, the subjects under investigation, and demands, have caused the services of the Section to be of use to many parts of the state.

Our bulletin mailing lists show a total of 5,800 names, of which about 3,500 are in Colorado; 300 are sent to newspapers and periodicals in Colorado, and 800 to periodicals, exchanges, institutions and individuals in other states, and 1,200 to Experiment Stations. This list should be increased in this state. It is intended to rearrange and classify the mailing list so that people desiring only a special line of bulletins need not be sent the whole list. We should encourage the preservation of bulletins for permanent use, and when the available number is small, give preference to those who preserve them. A file of bulletins becomes of considerable value, greater as the file is complete, and this is not less true of our own than of other states. Our earlier bulletins are already rare and difficult to obtain. That they are appreciated by some is seen from the fact that as high as $5 has been offered for copies of single bulletins. The

question of how best to reach the individual who uses the results, will be more seriously considered in the management of the Station. Our list should be greater. We need a more intimate connection with the agricultural communities.

Press bulletins are under consideration, and within limits, are looked on with favor. The large bulletins too often do not reach the individual who may be benefited. How best to do this will always be a problem. It is evident that many do not take time to read the bulletin, which can not be issued promptly to meet any sudden need. Some medium of promptly communicating to the public any important information, the result of investigations which, from their character or incompleteness, are not adapted for a bulletin proper, or other information, is needed. Under our conditions, with agricultural papers few in number, and with diversified interests in the state, such a series must be sent to a larger list of individuals than where local and agricultural papers form a more complete medium of distribution.

Besides the bulletins as a means of communicating the results of researches to those interested, the members of the staff have freely attended such farmers' institutes as have requested their services. While these take time and extra work, the personal contact with the farmer under conditions favorable to an understanding of the problems in the various parts of the state, is an advantage to the worker on the Station.

During the fiscal year the following bulletins were issued and distributed:

No. 47. Colorado's Worst Insect Pests and Their Remedies. 54 pp., 36 ill., by C. P. Gillette.

No. 48. Losses from Canals from Filtration or Seepage. 36 pp., 2 figs., by L. G. Carpenter.

No. 49. Meteorology of 1897, with Illustrations. 72 pp., 18 figs., by L. G. Carpenter and R. E. Trimble.

No. 50. Notes on Plum Culture. 48 pp., 18 plates, by C. S. Crandall.

No. 51. Sugar Beets in Colorado in 1898. 44 pp., by W. W. Cooke.

No. 52. I. Pasturing Sheep on Alfalfa. II. Raising Early Lambs, by W. W. Cooke.

The Station consists of five sections and two sub-stations. The plans for work for the year are shown in the outlines submitted with this report. A description of the principal features of the work is contained in the reports of the sections and by the sub-stations, to which your attention is called. There are other details, lists of fruit, records of weather, etc., which are desirable to make a matter of record, but have not been asked for this report.

The work of the Station on sugar beets has had much to do with calling attention to the adaptability of Colorado for the production of sugar. Bulletins 7, 11, 14, 21, 36, 42, 46, and 51 have been given to this subject, besides the data given in the various reports. One factory is already built, and two others are expected to be in operation for the crop of another season.

The Entomologist has rendered valuable aid with the insect pests which have shown themselves. A special press bulletin was issued in August to place a knowledge of the means to combat the insect in the hands of every one needing it. A copy was sent to every person in the state who was known to be growing sugar beets for factory purposes.

Some work done by the Botanical Section and the superintendent of the Arkansas Valley Station, in attempting to combat the ravages of blight affecting the cantaloupe industry, gives promise of success.

Work in continuation of the study of the water resources of the state was continued by the Irrigation Engineer. Several hundred miles of streams were measured in detail, and measurements and study continued on a number of farms and orchards, many of them in the Arkansas valley.

The sub-stations also present their work. Both superintendents have worked earnestly and conscientiously, but under difficult circumstances. The prevailing idea of a Station farm is, that it should be a model farm, and should do better in each crop than the specialist. These are impossible expectations. More than that, as defined by the Department of Agriculture, it is not the function of an Experiment Station. The idea, however, hampers the work. The cost of farm operations is great and does not produce an adequate return for the outlay. The lines in which the Station has accomplished the most, with small outlay, is where the work has been carried on largely with the cooperation of individuals. The farming features at both the main Station and the sub-stations have met with sharp criticism from the United States Department of Agriculture, who say that it is not only an illegal use of the Hatch fund, but it is unfair to the other farming communities to confine the work to a favored locality. The fact that the results from co-operative work, where individuals throughout the state have furnished the fields and equipment, has given more results at a far less expense, shows, as a business proposition, the advisability of changing the character of the work at the sub-stations.

The sub-stations have cost the Hatch fund in round numbers:

Plains Station	$ 7,200
Divide	8,000
San Luis Valley	15,400
Arkansas Valley	28,000

There have been receipts of $9,200 from the Arkansas Valley, and $2,000 from the others. This reduces the net outlay, but can not be returned to the Hatch fund.

The Arkansas Valley Sub-station is located about two miles east of Rocky Ford. At first it was called Bent County Station, but on the division of that county, its name was changed to the present

one. The land had been under lease to Hon. G. W. Swink, but was relinquished by him and the land deeded by the state to the State Board of Agriculture "so long as it should be used for an Experiment Station." For the past two years 120 acres have been leased, leaving 80 acres under the supervision of the superintendent, of which perhaps the larger part may be termed farm crops, raised experimentally. The lines of investigation have been many. The superintendent has been faithful and devoted, but has been under difficult conditions. During the past year some time has been given to the work on problems off the Station farm, and, as in these cases the superintendent does not have to attend to other than the questions under investigation, the results reached are of greater value and the expenditure little beside the time required. More of such work is needed, in other lines than cantaloupe blight and the codling moth. The sugar beet questions of that valley will bring a host of questions, where the time of such a man can do far more than can possibly be done on the Station farm, and the conditions there need such aid from us. The cost of the Station, from the Hatch fund, has been $27,999.14. It has given receipts of $9,164.26 (which could not enter the Hatch fund), or a net cost of about $19,000.

The name of the Rainbelt Sub-station has been changed to the Plains Sub-station.

The Rainbelt Station was established in Tp. 14 S Range 44 W, by the legislature of 1893. A sum of $2,500 was appropriated by the legislature, and $1,200 furnished by the community. The Station was opened in 1892, on land conditionally deeded by the Union Pacific railway. The present superintendent, a graduate of the Kansas Agricultural College, took charge in 1896. The grounds of the Station show almost the only spot of green along the line of the railroad for a couple hundred of miles. The plains are well worthy of careful

J. D. STANNARD, PHOTO.

Fig. 3. FORESTS AND SNOW. Snow Drifts in Green Timber June 21, 1899.
Elevation 9000 ft. Looking East.

J. D. STANNARD, PHOTO.

Fig. 4. From same point as Fig. 3. Same date. Looking Southwest into unprotected area.

and prolonged investigation. The nature of the questions negatives the idea of immediate results along the most important lines, yet the work already done makes it seem more than hopeful. With a limited sum of money the time of the superintendent is the principal available means. It is certain that the present arrangement, whereby the superintendent is tied down by the exacting demands of the area under cultivation, is not calculated to give the best returns. An arrangement by which the superintendent may be enabled to study the Plains in a broader way, and to study the methods already tried by others in eastern Colorado, will furnish a fund of information which may save some costly experience, and will result in more positive gains. Even if means should be found to continue the Station on the present lines, such a method would be the best in results.

The total cost of the Station, to date, has been approximately $7,200.

Calling this Station the Rainbelt substation has given apparent support to a notion at one time prevalent of a belt in eastern Colorado with more rainfall than the plains either east or west, and with enough for ordinary agriculture. This discredits the station at the outset, for while its purpose is to find the truth, it appears under the shadow of a false claim. As this station comes immediately in contact with questions of the plains, and these are the ones which justify its continuance, it would be well to call it in future the Plains substation.

The San Luis Valley Substation was organized in 1888, on land deeded conditionally to the State Board of Agriculture.

The location was poor, and several exchanges were made before the present location was obtained. It consists of 160 acres deeded to the State Board of Agriculture, so long as used for the purpose

of maintaining an Experiment Station. In 1896 the area was leased to the former superintendent on condition that he do some stipulated experimental work, and for three following years to J. H. Stone. A team of horses and some farm implements are still owned by the Station. As there is no immediate prospect of opening the Station, it would seem advisable to sell or otherwise dispose of these.

The total expenditure on this Station since its organization has been approximately $15,408.97, with receipts of $1,968.77, a net cost of $13,440.20.

The Divide Substation is located on the summit of the high ridge between the Arkansas and the Platte rivers, east of Palmer Lake.

In July, 1888, the State Board of Agriculture leased 640 acres of school lands in section 16, Tp. 11, R 64 W, for $32 annually. Two payments were made on the lease, but no other expenditures. In 1890 a tract of 40 acres was provided by subscription of various citizens of Monument, and a deed given to the State Board of Agriculture conditional on its use as an Experiment Station. If abandoned for this purpose, before the expiration of ten years, it is to be coveyed to Perry M. Kean, as trustee. Such trustee shall cause the land and improvements to be appraised separately by three disinterested persons, after which the lands and improvements are to be sold, the proceeds from improvements paid to the State Board of Agriculture, and the balance divided among the contributors. Early in 1896, with the lack of expected appropriations from the state, the movable property was sold, and the premises leased to W. A. Diebold, who still leases them at the same rate of $40 per annum. The buildings have been inventoried for several years at $700.

During the time of its existence, the expenditures on the Divide Station have amounted to $8,085.06.

Mr. Diebold reported for 1899:

"The crops, this year, are almost a failure. The crops consist of 12 acres of wheat, drilled in on fall plowing, yielding 46 bushels, all told. Fifteen acres of oats, plowed in, yielded 87½ bushels. The ground is in good condition for another year. The buildings need repairing and painting badly."

In closing, it may be added, that the field for the Experiment Station in Colorado is extensive as well as varied. In addition to nearly all the questions which meet the stations of the east, there are the special and extensive problems arising from agriculture by irrigation. While the results of investigations in other lines can be applied in Colorado to a great extent, in this line the western stations must depend on themselves. With limited funds and limited time, it becomes a question to what extent it is wise for us to attempt to cover all the interesting questions which arise. The station has acquired a strong hold on the people of the state, and it is hoped that it will none the less deserve their respect and confidence in the future.

Respectfully submitted,
L. G. CARPENTER,
Director.

Fort Collins, Colorado,
December 11, 1899.

INVENTORY.

Office fixtures and equipment	$ 347 75	
Stationery supplies	52 25	
Bulletin library	500 00	
		$ 900 00
Agricultural Section—		
Dairy supplies	$ 380 00	
Implements and tools	75 00	
Office equipment and miscellaneous	435 00	
		$ 890 00
Entomological Section—		
Laboratory supplies	$ 73 95	
Entomological supplies	75 65	
Insecticides and insecticide apparatus	90 95	
Apiary	138 45	
Station microscope, etc	335 00	
		$ 715 00
Horticultural Section—		
Glassware	$ 6 74	
Photographic apparatus and supplies	94 35	
Instruments	43 00	
Trees and nursery stock	322 40	
Miscellaneous	1 25	
		$ 467 74
Meterological and Irrigation Engineering Section—		
Meteorological instruments	$ 540 19	
Hydraulic apparatus	181 75	
Stationery, books, maps, etc	163 42	
Irrigation apparatus	134 03	
Instruments	72 25	
Miscellaneous	12 50	
		$ 1,104 14
Library—		
		$ 1,100 00
Total Main Station		$ 5,176 88

Arkansas Valley Substation—

Water rights and apparatus		$1,846 00	
Fencing, gates and bridges		357 80	
Buildings and improvements—			
Dwelling	$900 00		
Barn	750 00		
Sheds and out buildings	160 00		
Set farm scales	60 00		
Weather instruments and shelter	15 00		
		$1,885 00	
Live stock 4 horses, 8 hogs		216 00	
Implements and tools		459 60	
Miscellaneous		41 15	
Farm produce on hand—			
95 tons alfalfa hay	$285 00		
55 bushels barley	33 00		
550 " corn	165 00		
320 " oats	112 00		
175 " wheat	105 00		
150 " rye	90 00		
9 " peas	6 95		
15 tons sugar beets	45 00		
1000 pounds coffee beans	10 00		
2000 " cow peas	20 00		
2500 " potatoes	18 75		
60 " cantaloupe seed	30 00		
Miscellaneous	10 00		
		$ 930 70	
			$ 5,736 25

Substation at Cheyenne Wells—

Dwelling and barn	$800 00		
940 rods fencing	100 00		
3000 feet supply pipe (iron)	60 00		
		$ 960 00	
Two horses		50 00	
Farm implements		136 15	
Apparatus		104 05	
Supplies on hand		97 60	
			$ 1,347 80

Substation at Monte Vista—

Buildings, fencing, etc	$1,497 00	
One team of horses	150 00	
Farm implements	82 15	
		$ 1,729 15

Substation at the Divide—

Buildings		$ 729 00
Total Substation Property		$ 9,513 20
Total Main Station Property		5,176 88
Total Experiment Station Property		$14,690 08

In addition, the Station has the use and control of other property, as long as used for experiment station purposes, as follows:

160 acres at Cheyenne Wells		$ 200 00	
40 acres at Monument		200 00	
160 acres at Monte Vista		2,110 00	
Water right in Rio Grande Canal		300 00	
Arkansas Valley Substation—			
40 acres garden and fruit land at $85	$3,400 00		
160 acres farm land at $40	6,400 00		
		$9,800 00	
			$12,610 00

This has previously been counted as part of Experiment Station property. As the title is conditional only, it is thought proper to list it separately.

OUTLINES OF STATION WORK FOR 1899.

The schedules of station work for the year were presented, revised, and adopted. These schedules were adopted at a regular monthly meeting of the Executive Committee. The outlines of experimental work for the different sections of the Home Station and the substations, located at Rocky Ford and Cheyenne Wells, are herewith given:

AGRICULTURAL SECTION.

Wheat—

Tests of the effect of changing from a higher to a lower altitude and from a lower to a higher; the same for latitude and for both combined.

These tests are to be made in co-operation with the experiment stations of North Dakota, Minnesota, and Iowa, and with local observers in Colorado in the San Luis Valley and on both sides of the range. Duplicates of all tests to be made at Fort Collins.

These tests are designed to show the effects on the milling qualities, the bread making qualities, and the value of grain for human food.

Tests for improving wheat by selection so as to increase the amount of gluten and decrease the proportion of bran.

Tests to develop a variety of wheat that will ripen with a smaller amount of water than is now required.

Oats—

Tests of the effect of changes of altitude to be made at Fort Collins and in connection with volunteer observers in the mountains and on the Western Slope.

Tests for the development of a variety of oats better suited for human food.

Tests for the development of a variety of oats with a thinner husk.

Barley—

An endeavor to produce a variety that will ripen seed with fourteen inches annual rainfall.

Peas and Oats—

An endeavor to learn why peas or peas and oats do not grow well in this vicinity.

Corn—

Third and last year of the three years' test of seed from different altitudes and latitudes.

Alfalfa—

Co-operative experiments with Turkestan alfalfa to find out its adaptability as a crop for the Divide without irrigation.

Brome Grass—

Test of its feeding value per acre as a pasture for sheep.

Dwarf Essex Rape as a pasture for sheep.
Sugar Beets for the production of seed.

Co-operative experiments with twenty-three persons in the irrigated parts of Coloredo.

Feeding Tests—

Continuation of the present tests in feeding cows, sheep, and hogs.

Creameries—

Collections of statistics from all the creameries and cheese factories as the basis for a bulletin on the dairy industry of Colorado.

Land Plaster—

Second year of the experiments on alfalfa and grain crops, extending the experiments to include pasture land.

SECTION OF BOTANY AND HORTICULTURE.

I. The study of the Flora of the state, special attention being given to:

1. The weeds of the farm and garden.
2. Grasses, native and introduced.

II. The further introduction to the garden of such wild fruits as can be obtained.

III. Nursery test of orchard fruits with a view to the study of the adaptibility of varieties to this climate.

(a) A study of the blooming periods of varieties of plums.
(b) A study of the degree of self sterility in plums.

IV. Tests of varieties of small fruits.

V. Co-operative work with the Division of Forestry of the U. S. Department of Agriculture.

It is also proposed to continue the work of last season with different methods of grafting, and with crossing.

CHEMICAL SECTION.

I. Continuation of work on part II of Bulletin No. 46, "A Soil Study.

II. A study of methods used in extracting beeswax from old combs.

III. Study of Colorado grasses in co operation with the Department of Botany.

IV. A digestion experiment with sheep. This is intended to be supplemental to Bulletin No. 39.

This work, already begun, will require more than a year for completion.

ENTOMOLOGICAL SECTION.

I. Collecting and rearing insects for the purpose of determining their food habits and life histories.

II. Continuation of experiments for the destruction of insect eggs.

III. A continuation of the Orthopterological survey of the state.

The object of the work taken up under this head is, not alone to collect and determine the Orthoptera (mainly grasshoppers and locusts) that occur in different localities of the state, but also to determine, as far as possible, their food habits, life histories, diseases, enemies and artificial remedies.

IV. Experiments with the Codling Moth.

(a) To determine the value of kerosene emulsion for the destruction of this insect.

(b) To determine the number of broods and the times of their appearing in the different apple-growing regions of the state.

(c) To determine the value of arsenical sprays for the destruction of the different broods, and the real saving due to spraying.

V. A study of the habits of the "ash borer" which in the past two or three years has become so destructive to ash shade trees in and about Denver.

The main object of the study will be to determine the most effectual methods of suppressing the borer.

VI. Experiments in the apiary.

(a) A continuation of the work of collecting and making a list of the native forage plants of the state.

(b) Experiments with comb foundation.

(c) Testing new apiary appliances.

SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING.

I. Meteorology as before.

II. Evaporation from water surface, extending to soils and vegetation to some extent.

III. Soil moisture determinataions.

IV. Soil temperatures.

V. The irrigation questions of the state.

(a) San Luis Valley.

(b) Arkansas Valley.

VI. Seepage measurements.

VII. Sediment determination of the Arkansas Valley.

VIII. The effect of forests on retention of snow and water supply.

ARKANSAS VALLEY SUBSTATION.

Rocky Ford, Colorado.

CEREALS.

1. *Wheat*—A comparative test of varieties shown last fall.
2. *Rye*—Four acres of Mammoth Spring rye.
3. *Barley*—Three acres of Hulless Barley.
4. *Corn*—Two acres to be divided for a test of cultivation *versus* irrigation; a few varieties tested for productiveness and time of maturity.

GRASSES AND CLOVERS.

1. *Bromus inermis*—One and one-half acres sown last fall to be used for pasture.
2. *Orchard Grass*—One and one-half acres for pasture.
3. *Australian rye and Tall Meadow oats*—A test plat of one-eighth acre each.
4. *Alfalfa*—The sowing of last fall to be compared with spring sowing; small area sown in furrows to note the effect of sub-irrigation and cultivation. Test Turkestan alfalfa for growth and adaptability.
5. *Cow Pea*—A test of a few varieties for date of ripening and yield; sown in a portion of the orchard to test it as a cover crop and fertilizer for orchards.
6. *Hairy Vetch*—Additional plantings to those we have to test it for pasture, cover crop, and fertilizer.
7. *Soja Bean*—One-eighth acre to secure seed for future use.
8. *Field Peas*—One acre under general farm conditions to show their value as a forage and grain crop.
9. *Coffee Pea*—Same as above.

VEGETABLES.

1. *Cantaloupes*—
   (a) Tests of different amounts of irrigation as affecting quality and production.
   (b) Alfalfa sod *versus* natural soil.
   (c) Three distances of planting to note yield and condition.
   (d) What effect injudicious seed selection has upon the future crop.
   (e) Seed to be selected from perfect specimens and held for distribution to help maintain a high quality of product.
   (f) Notes upon, and work with, insects and fungi affecting this crop.

2. *Celery*—Small area devoted to this crop to note the general requirements.

3. *Potatoes*—About one-half acre to be planted to one variety to note the following:
   (a) Comparison of different dates of planting.
   (b) Irrigation experiments.
   (c) Sod land *versus* cultivated soil.
   (d) Small area planted with Mammoth Pearl variety for seed.

4. *Sugar Beets*—One acre to be grown by field culture and a record kept of the cost; such information for the benefit of those wishing to grow them for feeding or factory purpose.

Beans—Planting and spraying trials to control the blight.

ORCHARDS AND FRUITS.

1. *Old Orchard*—
   (a) Notes on blooming, fruiting, etc.
   (b) Spraying and band experiments with the codling moth in connection with the Entomological Section
   (c) Observations with the blight and experiments connected with the pruning of trees affected by it.

2. *New Orchard*—
   (a) Vacancies to be filled with new and untried varieties of fruit and nut trees.
   (b) Establishment of a test plat of nut trees to be grown from seed.

3. *Small Fruits*—Securing strawberry plants to fill vacant places caused by the hail.

4. Variety tests of blackberries and raspberries.

5. *Grapes*—Establishing a test of of foreign kinds.

ENTOMOLOGY.

Observations upon injurious insects; spraying and other remedies for their control.

METEOROLOGY.

Continuation of present records.

FERTILIZERS.

1. Gypsum to be used upon about one acre of "black alkali" soil to note its value in reclaiming the same. Note its effect upon crops grown where it was spread the previous year.

2. Ground bone and wood ashes to be used upon a few apple trees of bearing age to note the effect upon health, and productiveness.

The remainder of the station land to be devoted to such crops as will be of most feeding and commercial value.

RAINBELT SUBSTATION.

Cheyenne Wells, Colo.

I.

I. Fall grain already sown—
  1. Wheat, 2 acres,
  2. Winter oats, 2 acres,
  3. Winter rye, 1 acres. 5 acres.

II. Campbell Test—
  1. Corn, 5 acres,
  2. Barley, 2 acres,
  3. Sorghum, 3 acres,
  4. Truck patch, ½ acre,
  5. Sweet corn, ½ acre,
  6. Potatoes, 1 acre. 12 acres.

III. Alfalfa—
  1. Already growing, ½ acre,
  2. To be sown, 5 acres. 5½ acres.

IV. Grasses and Clovers—
  1. *Bromus inermis*, growing, 2 acres,
  2. *Bromus inermis*, to be sown, 1½ acres,
  3. Other grasses and clovers, ½ acre. 4 acres.

V. Seeds of several forest trees.

VI. Extend test of fruits to include currants, blackberries, dewberries, strawberries, Russian cherries, peaches, apricots, etc.

VII. Plant 3,000 seedling trees—apple and forest—in nursery

for use later in making shelter belts and orchard in plat through which the ravine runs.

VIII. All cultivated land not used otherwise to be planted to millet, barley and sorghum for forage. Accounts to be kept to determine cost of producing fodder or hay.

IX. Test improving pasture.

1. By furrows drawn across slopes.
2. By running disc harrow across slopes.

(To hold water where it falls.

X. Improve ponds in ravine by dams.

XI. Investigate, by correspondence and travel, the results of the efforts of settlers to raise crops and grow trees.

XII. Further use of gypsum on different crops; test of Russian forage plants in co-operation with the U. S. Department of Agriculture.

II.

I. Continue soil investigations of former years:

1. Evaporation from soil surface.
2. Evaporation from soil surface, using soil mulch of different depths to retain moisture.

II. Evaporation from water surface, a continuation of the work of 1898.

III. Test amount of water used by growing crop of wheat already planted.

IV. Test amount of water used by growing crops of corn.

V. Continue meteorological observations.

VI. Autumn work—

1. Wheat, 2 acres,
2. Oats, 2 acres,
3. Barley, 2 acres,
4. Rye, 1 acre. 7 acres.

(To be sown late in summer for a soil cover.)

VII. Co-operation with U. S. Department of Forestry in planting a few acres of forest trees on the station land.

REPORT OF THE AGRICULTURAL SECTION.

To the Executive Committee of the State Board of Agriculture.

GENLTEMEN—I have the honor to submit herewith the report of the Agricultural Section for the past year.

The experimental work of this section has been conducted along three general lines, *i. e.*, the raising of crops experimentally on the college farm; the feeding of stock and the conducting of co-operative experiments with farmers throughout the State. During the past season the third and final year's work was completed on the subject of the effect of altitude and latitude on the growth of corn to be used for seed, in Colorado, and the results are now ready to be written up for publication.

We have also completed three years work on making ensilage from corn and feeding it to cattle and sheep. This finishes the work that had been contemplated in that line, and we plan to begin, in 1900, a series of tests on alfalfa ensilage. In general it may be said that our work shows that corn ensilage cannot profitably be used under present Colorado conditions, as a food for either cattle or sheep that are being fattened out doors during cold weather. Our tests with dairy cows gave no conclusive results either way, but are not favorable to ensilage.

The number of calls that have come for the bulletin issued last spring on the raising of early lambs, shows that many farmers are contemplating this method for disposing of their alfalfa. To continue these tests along slightly different lines, forty ewes have recently been purchased, and they and their lambs will be fed for next summer's market.

During the past season two series of co-opera-

tive experiments were carried on in Colorado. The first was to determine the best time and the proper distance apart to plant sugar beets. The results of these tests are not yet all on hand. This Section has devoted a great deal of time the past three years to the sugar beet question, and the interest in the matter throughout the state is greater now than ever before. At the present time there is no work that can be done by the Section that will be of greater good, or will bring more immediate results, than investigations along this line. The field is unlimited, and the more it is investigated the plainer becomes the fact that the problem in Colorado is radically different from that in any other portion of the world where sugar beets are grown. The problems will have to be worked out independently for the Colorado farmers. At the same time, what has been accomplished so far is very gratifying, and the outlook for the industry in Colorado was never brighter.

The first of a five-years' test of a new variety of alfalfa has been conducted, and all that can be said at the present time is, that the test was gotten fairly under way.

The larger part of the energies of this Section has been devoted the past season to the beginning of a series of tests of the influence of latitude, and especially latitude and altitude combined, on the growth of cereals, especially wheat and oats, and on their value as stock food and as human food. The results of the first year's work are quite gratifying, but though an enormous amount of work was put on the questiôn, and much yet remains to be done in working up the results of the 1899 crop, yet the most we can claim is, that a fair start has been made. These tests were made at the college farm, and five other farms in Colorado, and with the co-operation of four other experiment stations and the Department of Agriculture, at Washington.

Three more cows have just been purchased, to be used in connection with those on hand in tests

of the feeding value of sugar beets and mangels, and it is expected that we will be able to conduct some tests on the feeding of beet pulp, which is destined in the very near future to play an important part in the stock feeding of Colorado.

Respectfully submitted,
W. W. COOKE,
Agriculturist.

Fort Collins, Colorado,
December 1, 1899.

REPORT OF THE SECTION OF BOTANY AND HORTICULTURE.

To the Executive Committee of the State Board of Agriculture.

Gentlemen—I have the honor to submit the following report on the work of the Section of Botany and Horticulture.

The horticultural work of the Section has been mainly the continuation of the systematic test of varieties of fruits which was commenced in 1894.

The plum orchard, which, in 1898, contained 152 varieties, was reported on in Bulletin No. 50, "Notes on Plum Culture," which was issued early last spring. The lines of study there recorded have been followed this season, and records are on file giving blooming periods of varieties, the results of studies in self-sterility, and further observations upon the characteristics of varieties.

The continuous and unprecedented low temperatures of the winter of 1898-99 did much damage to the plum orchard and was a severe test for even the hardiest varieties. Thirty varieties were entirely killed. These were destributed in the following groups: Chicasaw, 5; Beach Plum, 1; Wild Goose, 6; Domestica, 6; Japanese, 7; Americana, 4; and hybrids, 1. Eighty varieties are recorded as having been very seriously injured, these are dis-

tributed through all groups, and the individual injury varies between killing to the ground and the loss of the greater portion of the top. The ten Japanese varieties not killed outright were dead to the ground. The balance of the varieties represented are recorded as uninjured or killed back only at the tips of the branches. These with the exception of a few of the Miner group, belong to the native Americana group.

It cannot be said that any variety escaped injury; even the hardiest that were uninjured in branch or twig were very tardy in opening the leaf bud, and the flower buds were nearly all killed. Individual trees of 44 varieties produced some bloom. Of these 37 were Americana varieties, five belong to the Miner group, two were unclassified hybrids, and one was *Prunus Besseyi*. On all the flowers were thinly scattered, sometimes not more than a dozen on a tree. They were small in size, very tardy in expanding, and but few formed fruit. This evident lack of vitality in the flowers, and their small numbers, rendered the work on flower periods and sterility unsatisfactory. The conditions being abnormal, the results obtained cannot be used as a basis for conclusions, but will be preserved for comparison with other years.

To, in part, replace the trees killed, 74 trees, representing 40 varieties, were planted last spring. Seven of these varieties had not been previously represented in the collection. As the orchard now stands, it contains 507 trees, representing 137 varieties. Most of the living trees made a fair growth during the season and have formed buds that promise a handsome abundant bloom next spring.

The young apple orchard suffered even greater loss than did the plum orchard. As reported a year ago, the trees were not in thrifty condition, having suffered from lack of water, and it was not surprising that so many were killed. The number

killed outright was 150, and many others were severely injured. From a count just made it appears that there are left about 300 trees that are of sufficient promise to warrant transplanting and further care, as directed by your committee when the orchard was inspected in June. It is hoped that arrangements can be made to locate the orchard on land where water for irrigation is available.

The co-operative experiment with the Division of the United States Department of Agriculture, to test the relative hardiness of forest-tree seedlings as grown from seeds produced in different sections of the country, has apparently been abandoned, as no word regarding it has been received this season. The seedlings grown in 1897, and those of 1898, which together represent seven species from 23 states and Canada, have been transplanted and cultivated through this season. Records have been kept of vigor of growth and hardiness, and the tabulations show some interesting results, pointing to the correctness of the belief that northern grown seeds produce the hardiest seedlings. While not regarded as conclusive, the test is sufficiently instructive to warrant preparation of the data for publication.

The abandonment by the Forestry Division of the Department of Agriculture, of the forest plantation commenced in 1896, renders it necessary that some action should be taken regarding the disposition of the land set apart for this purpose. No work has been done upon the plats since July, 1898, and upon a portion of the area weeds have become abundant. There are four plats of one acre each, on which are growing several thousand trees. The pines and spruces have nearly all died, but deciduous species have, in general, lived and made some growth. Of living trees, the aspen is most numerous, but there are many locust, soft maple, black cherry and boxelder, with a few of elm, mulberry, birch and ash. On one plat are nearly 4,000

plants of Southernwood (*Artemisia abrotanum*), of spreading, shrubby growth, about four feet high, and among these are a few aspen, elm and silver maple. This species was planted as a nurse plant for conifers; it covers the ground completely and serves well the purpose of protecting other plants, but it is of no other use as it kills to the ground each winter. If the land is not needed for other purposes, I believe the plantation should be maintained. Possibly some additions could be made until we have a compact growth of trees, which will serve as a source of supply for planting on other portions of the farm, and as an illustration of the behavior of different species when grown under forest conditions. To bring the plants into good condition will require some expenditure of labor, but I believe the plantation would soon take care of itself, and in time give valuable returns for the investment.

The work on the flora of the state has advanced but little during the season. Neither time nor means were available for prosecuting the work of collecting. One brief trip to the Western Slope, which allowed but one day for collecting, was made in May. In late July and extending into August, a trip of three weeks, during vacation, was made into the North Park region for the special purpose of studying grasses and the methods of irrigating meadows. Large collections of grasses and many additions to the general flora were secured, although the work was seriously hampered by the frequent rains. It would be very desirable that similar expeditions be made in South Park and the San Luis valley, so that the forage problems of these high park regions could be compared and treated in one publication. The grass problem of the plains region is so different in character that it could best be treated separately. It is no less important and should receive attention.

Late in October a short trip into the mountains west of Fort Collins, was made for the pur-

pose of collecting seeds, particularly of the pines and spruces.

About 1,800 specimens of plants for the herbarium have been received in exchange during the year. They are as yet unmounted, but it is hoped that they may be mounted and arranged for use during the winter. The number of exchanges could be greatly increased if we had the assistance necessary in preparing the plants for sending out. Several offers of exchange have been declined because no time was available for the work involved.

Last year I reported upon several fungus diseases sent in from various parts of the state. This year the number received has been greater, and it is becoming more and more evident that this matter of the diseases of plants must become an important feature of the work of the section. The cantaloupe disease, at Rocky Ford, did great damage to the crop this season, and is worthy of persistent attention by the Station. In September I visited this section and, in company with Mr. Griffin, went over many diseased fields. That the crop was shortened, and in many cases entirely ruined by the disease was apparent. Early in the season Mr. Griffin made applications of Bordeaux mixture in several places to small areas. The results have been encouraging, and next season a thorough demonstration of the beneficial effects of the treatment should be made. This work is important to the cantaloupe industry, and I believe would reflect credit upon the Station.

Respectfully submitted,

C. S. CRANDALL,

Botanist and Horticulturist.

Fort Collins, Colorado,

December 1, 1899.

REPORT OF THE ENTOMOLOGICAL SECTION.

To the Executive Committee of the State Board of Agriculture:

Gentlmen—I have the honor to submit the following report upon the work of the Entomological Section of the Experiment Station for the year just closing:

CODLING MOTH.

Experiments with the codling moth have been continued, particularly for the purpose of determining the number of broods of this insect in Colorado. A series of experiments were carried out at the Home Station, and similar ones at Rocky Ford, by Mr. Griffin, and by others at Canon City and Grand Junction. Reports have not yet been received from the last named place, but data gathered by Mr. Griffin, at Rocky Ford, Doctor Peare, of Canon City, and from our experiments here prove very conclusively that this insect is wholly two-brooded, with no indication of a third brood in these localities. The experiments give further proof, also, of the importance of the bandage system of fighting this insect.

Kerosene emulsion has also been tried as a remedy this year, but the results do not warrant recommending its use. Prompt and thorough use of arsenical sprays still remains our most reliable remedy.

ORTHOPTEROLOGICAL SURVEY.

Good progress has been made in the study of the grasshoppers of the state. Several species, not known to occur here before, have been taken, and among these are a few species that are as yet unknown to science.

It was thought by many that the unusually

cold winter of 1898-99 would greatly lessen the number of grasshoppers for a few years, but such does not seem to have been the case.

A reported visitation of the Rocky Mountain locust, on the eastern border of the state early in July, was the occasion of a trip, by Mr. E. D. Ball, over the line of the Burlington railroad as far as Stratton, Nebraska, where it was reported that the locusts were in greatest numbers. Mr. Ball found the injuries to be due almost entirely to two common species that are present every year, namely, the two-lined locust (*Melanoplus bivittatus*) and the differential locust (*Melanoplus differentialis*). No specimens of the Rocky Mountain locust were found, and, in fact, for a considerable number of years, this destructive insect has not been recorded with certainty, from the state; and we believe it is fairly safe to predict that the terrible periods of devastation of this insect within our borders is a thing of the past. In all our collecting of insects over the state for the past nine years, not a specimen of the Rocky Mountain locust has been seen.

A trip through the San Luis valley was made by myself in the month of August for the purpose of studying grasshopper conditions, and I am glad to state that in no place were grasshoppers found to be doing perceptible injury to cultivated crops, though native species were abundant over much of the wild pasture land.

During a trip to the western portion of the state, with stops at Salida, Gunnison, Delta and Grand Junction, grasshoppers were found relatively scarce at the two former places, while in many places about Delta and Grand Junction they were doing serious harm to cultivated crops, and especially alfalfa and orchard trees. In these localities, also, the two-lined locust and the differential locust were the chief depredators.

Mr. E. S. G. Titus made a trip into the southern portion of the state, and Mr. E. D. Ball a

somewhat extended one into the foothills and plains of the northern portion, gathering information which we hope to incorporate into a bulletin at some later date.

THE BEET ARMY-WORM (*Laphygma flavimaculata*). *

This insect, which is a close relative of the "Army-worm," and particularly of the "Fall Army-worm," has been known for many years to occur in small numbers in various parts of the country, but has never been known as a destructive insect until the past summer, when it appeared in many localities in injurious numbers. The most remarkable outbreak that has come to our notice was about Grand Junction, Delta and Montrose, during the month of August. The sugar beet was chiefly attacked, though the caterpillars showed themselves to be capable of living upon almost any green thing that could furnish them succulent vegetation for food. It was estimated that two or three hundred acres of the beets were completely ruined. When the leaves did not furnish sufficient food, the caterpillars did not hesitate to eat off the crown of the plant and devour the root also. Experiments tried in the field demonstated that the ordinary arsenical mixtures will destroy the worms if properly distributed upon the leaves.

Two trips were made to Grand Junction to study this insect, where I was shown every courtesy and greatly assisted in the work by the officers and managers of The Colorado Sugar Manufacturing company.

Advice was given to many individual growers, and to the Sugar company, as to remedies, and a press bulletin was written and mailed to all who were growing sugar beets in the localities above mentioned. The insect matured in enormous numbers, and is passing the winter as a moth. There is every reason to expect a recurrence of

* Determined by Dr. J. B. Smith, New Brunswick, N. J.

of the caterpillars next summer, at about the time for the thinning the beets, when growers will do well to keep a very close watch and be prompt in the application of arsenical poisons for the destruction of the first brood of caterpillars.

Mr. Griffin, of the Rocky Ford Station, also sent me a few caterpillars of this insect from beets grown on the Station grounds at that place.

THE ASH BORER (*Podosesia syringæ*).

This lepidopterous borer seems to be rapidly increasing in and about the city of Denver. It has killed many trees outright, and others are weakened and disfigured. A stump eighteen inches in length, from the grounds of Mr. E. Milleson, Horticultural Inspector for Arapahoe county, is in my office, from which over twenty moths hatched last summer.

INSECTICIDES.

Several arsenical mixtures have been tested the past summer to determine their effects upon foliage and upon insects. I will say, in brief, that of three proprietary compounds, viz: "green arsenoid," "pink arsenoid," and "white arsenoid," that we found the two former very promising and of easy application, while the last was too injurious to foliage to allow of its use. Arsenate of lead was also used and found to do no harm to the most tender foliage, in ordinary strengths, while it remained long upon the leaves and was destructive to the insects that ate it.

APIARY EXPERIMENTS.

The apiary experiments have been chiefly for the purpose of determining the best form of foundation to use for comb honey, and the best methods of using the foundation in the section. The experiments this year have proven, beyond a doubt, that bees do thin thick foundation and use the material thus obtained in building out comb cells.

It is expected to incorporate the results of these experiments in a bulletin at no distant date.

This Section is much in need of better accommodations for experimental and breeding-cage work. Such rooms as are needed could be built on to the present apiary building, at small cost, and would be of much service to the Entomological section. Respectfully submitted,

C. P. GILLETTE,
Entomologist.

REPORT OF THE CHEMICAL SECTION.

To the Executive Committee of the State Board of Agriculture.

GENTLEMEN—I have the honor to report that no changes have been made in the lines of investigation of the Department. The study which we have been making on the plot of ground west of the Town ditch south of the land running west from the College barn, has been continued during the past season. We have made no change in the plan pursued in former seasons. We have even continued the same crop. Part I. of this study has already been published, and the material for Part II. is nearing completion. This work has already passed far beyond the limits originally set for it.

The work in conjunction with the Botanical Department, on the grasses of the state, has scarcely passed beyond the preparatory stage, and cannot be taken up immediately.

The work on the methods of extracting beeswax, which is co-operative work in conjunction with the Department of Entomology, is well under way, but, like all work of this kind, will probably take a much longer time to complete than we even now expect.

We hope to finish the series of experiments on digestion of corn fodder, timothy hay, native

hay and alfalfa, with sheep, begun over a year ago, within the next few months.

This is the present state of the work in hand.

It is due to my assistants in particular, that I should state that the volume of work accomplished has been very considerable, and its quality excellent. I do not know of any misunderstanding, spirit of caviling, or any unpleasantness whatever existing among my assistants, either in their relations toward one another or toward myself.

I have no recommendations to offer at this time and no request to make.

Respectfully submitted,
W. P. HEADDEN.

Fort Collins, Colorado,
December 11, 1899.

REPORT OF THE METEOROLOGIST AND IRRIGATION ENGINEER.

During the past year the character of the investigations in progress is indicated by the outline of work, which has been essentially the same for a number of years.

SEEPAGE GAINS AND LOSSES.

The measurements to determine the gains or losses from seepage have been continued this year on streams previously measured. These include the Cache a la Poudre, from the canon to its mouth, a distance of 50 miles; the Big Thompson, about the same distance; the Little Thompson, a tributary of the Big Thompson; the St. Vrain from Lyons to the Platte, and its tributary, Left Hand Creek; the Rio Grande, from above Del Norte to the state line, a distance of about 100 miles; the Arkansas, from Canon City to the Kansas state line, a distance of 200 miles; nearly 500 miles of river measurement in all for this particular pur-

pose. Each of these streams requires driving the the full length, visiting every headgate, and the measurement of every ditch and every tributary. Altogether it has required several thousand miles of driving for this particular purpose. The general results of previous measurements are confirmed. A tendency to increase in the amount of water returning to the river is noticeable, especially on those streams where the return waters have some distance to pass to reach the stream. The Rio Grande is an exception, in that a marked loss is noticeable at the rim of the valley. There is then a gain, but not enough to balance the loss.

CACHE A LA POUDRE.

The fourteenth measurement of the Poudre, from the canon to the mouth, was made September 26th to 29th. The distance is about forty miles by the axis of the river, and much more by the sinuosities. The measurements prior to 1896 are given in detail in Bulletin No. 33. The following is a summary of the last four:

	1896 Nov.	1897 Oct.	1898 Aug.	1899 Sept.
Weir to water works	— 2.92	+ 1.39	+ 7.76	— 0.85
Water works to L. & W	?	+16.61	+ 9.16	+16.14
L. & W. to No. 2 Supply	— 5.68	— 3.96	+ 3.37	+10.13
Supply to Strauss bridge	—22.87	— 2.90	+14.84	— 1.12
Strauss to No. 2 canal	+16.41	+10.42	+ 1.28	+ 8.62
No. 2 to Eaton ditch	+10.42	+13.36	+ 8.34	+ 3.05
Eaton to No. 3 canal	+ 5.77	+35.72	+15.44	+13.74
No. 3 to mill power canal	+16.64	?	+21.16	+21.86
Mill power canal to Camp ditch	+25.52	+26.57	+25.98	+30.93
Camp ditch to mouth	+21.98	+23.58	+33.37	+31.62
			135.18	133.59

TOTAL GAINS ON THE CACHE A LA POUDRE—CANON TO MOUTH.

Year.	*Date.*	*Total in sec. feet.*	
1885	Oct. 12–15	86.9	
1889	Oct. 14–17	98.96	
1890	Oct. 16–18	100.8	
1891	Oct. 29–30	84.6	
1892	Mar. 10–12	96.1	plus from Ogilvy to mouth, about 30 ft.
	Oct. 5–8	101.65	
1893	Nov. 9–11	98.7	
1894	Mar. 13–15	82.3	
	Aug. 20–23	118.2	
1895	Oct. 9–14	164.4	
1896	Nov. 11–14	88.3	plus from New Mercer to L. & W. dam.
1897	Oct. 7–14	142.69	plus from No. 3 to Greeley pump house, probably 30 feet.
1898	Aug. 9–12	135.18	
1899	Sept. 27–30	133.59	

When brought to a uniform method of treatment these will be subject to slight changes. No allowance is made in the above for temperature.

Measurements in October, 1892, and in 1896 are affected by a periodical exchange of water between the Larimer & Weld canal and a mill at Fort Collins. The effect of this would extend to the Cache a la Poudre canal No. 2. In recent years there have been numerous seepage ditches constructed, and an increasing amount is intercepted by these ditches and by storage reservoirs.

The quantities given are those reaching the river; hence an allowance is to be made for the amount thus intercepted before an estimate strictly comparable with the earlier years can be made.

ON THE ST. VRAIN.

The St. Vrain creek rises in the high mass of mountains from Long's peak southward to the head waters of Boulder creek, and waters one of the most fertile of the tributary valleys of the Platte.

The following gains were found in the measurement made October 26–28, 1898, and in November, 1899, by Mr. Trimble, with the aid of Mr. L.

H. Dickson, of Longmont, Water Commissioner of District No. 5.

	Distance. Miles.	*Gain—sec. feet.* 1898	1899
From Lyons to the Oligarchy ditch	3.7	2.62	4.69
From the Oligarchy to the Niwot ditch	2.7	3.24	6.14
From the Niwot to Boulder-Weld county line.	6.7	7.39	12.21
County line to Boulder creek	2.2	5.34	21.60
Boulder creek to Fleming place	5.8	4.21	—.44
Fleming place to Platte river	7.0	2.98	—2.44
Total	28.0	25.79	41.76

LEFT HAND CREEK.

	Gain.
Star ditch to Holland ditch	1.01
Holland ditch to Williamson & Way	0.28
Williamson & Way to Burch school	0.44
Burch school to St. Vrain creek	4.01
Total	5.74
From both St. Vrain and Left Hand	47.50

The amount of land irrigated in Water District No. 5, which includes the St. Vrain and Left Hand creeks, is 89,000 acres, according to the report of Water Commissioner Dickson. This does not include the amount entering Boulder creek which is also a tributary of the St. Vrain.

THE BIG AND LITTLE THOMPSON.

The Big Thompson heads in the high mountains surrounding Estes Park. The highest is Long's peak, rising to 14,260 above sea level. An unusual proportion of the watershed has a northern aspect, so that the stream maintains its flow well. The head waters of the Little Thompson are but five miles east of Long's peak, from which they are separated by a transverse valley.

	Distance. Miles.	*Gains.* 1897 Nov. 5-8	1898 Nov. 2-3	1899 Nov. 16-17
Handy to Home Supply canal	1.0	0.0	.....	.....
Home Supply to Barnes ditch	5.7	15.78	8.13	8.88
Barnes ditch to Loveland & Greeley	3.1	4.62	3.52	0.86
Loveland & Greeley to Big Thompson ditch	10.05	12 38	13.31	1.38
Big Thompson ditch to Hill and Brush	5.3	4.52	6.62	10.85
Hill & Brush to the Big Thompson and Platte	10.6	12.42	9.59	5.74
Big Thompson and Platte to the Evans town ditch	11.0	14.36	11.59	9.67
Total	64.08	52.74	47.00	38.70

ON THE LITTLE THOMPSON.

	Distance Miles.	*Gains.* Nov. 13	Nov. 4	Nov. 17
From Eagle ditch to Dry creek	3	1.35	3.16	2.46
Dry creek to Rockwell ditch	2	2.77	1.52	2.16
Rockwell to Miner ditch	3	2.43	1.32	7.62
Miner ditch to mouth	6	4.08	2.89	6.89
Total	14	10.63	8·89	13.15
Total Big and Little Thompson		74.71	61.63	51.85

The amount of land irrigated from this stream is approximately 65,000 acres. An increasing amount of seepage is being intercepted by ditches and reservoirs.

THE RIO GRANDE.

The fourth measurement has been made on the Rio Grande, from the canon above Del Norte to a point near the New Mexico line. The elevation ranges from about 8,000 to about 7,000 feet above sea level. For this portion of its course the river passes through the San Luis Valley, an ancient lake bed surrounded on all sides by high mountains. Many streams enter the valley from the surrounding rim; but with few exceptions all

sink. It is found that the Rio Grande itself shows a large loss as it crosses the rim, and while it gains during the rest of its course in the valley, it is not enough to make up for the loss in the first three miles.

	1896.	1897.	1898.	1899.
From canon to Del Norte......			—51.69	—61.96
Prairie canal..............	—107.03	—72.09	+ 1.84	+ 4.53
to Montevista...........	+ 54.32	+ 6.61	+ 6.26	+ 2.46
San Luis canal............	— 5.68	+27.25	+ 8.82	+16.93
Hickory Jackson..........	+ 27.14	+42.10	+18.10	+36.10
Alamosa..................	+ 4.85	+ 7.45	+ 2.78	—13.78
Above Conejos................	+ 16.70	....	+ 1.57	— 2.64
Below "	— .41	+ 4.20	....	— 0.06
La Sauces.................	+ 5.27	+ 6.93	+ 0.92	+ 0.38
Iron bridge..	....	+ 9.23	....	— 1.78
Near State line...........	— 3.58	....	....	....
Total	— 8.42		—13.24	—15.59

In 1897 the section between Alamosa and Conejos river is vitiated by the omission of Trinchera Creek, a small stream ordinarily dry. This was reported on reliable evidence and not visited, but our comparisons afterwards make it probable that it was subject to a flood at the time. This stream was not measured in 1896, but was measured in 1898 and 1899.

THE ARKANSAS RIVER.

The third measurement was made on the Arkansas river from the canon above Canon City to the Kansas state line. The measurement was made from October 20th to November 3d. As the season was late, the measurement was begun at the Bessemer ditch, above Pueblo, and carried to the state line.

The following summary shows the seepage gains and losses that were found in 1897, 1898 and 1899, the measurements being given in cubic feet per second. The drainage area above Canon City is about 4,600 square miles:

Place.	Dist. Miles.	Area of Tribut'y Water-shed—square Miles.	1897 Gain.	1897 Loss.	1898 Gain.	1898 Loss.	1899 Gain.	1899 Loss
Canon Cy to Bessemer ditch..	33	1481	53.40	.....	55.17	.....	......	......
Bessemer to Pueblo	10	255	......	42.18	......	15.96	......	30.25
Pueblo to Orchard Grove..	8	1101	......	9.40	19.41	....	......	30.31
Orchard Grove to Boone.....	16	1335	103.47*	.....	20.30	....	......	7.55
Boone to Nepesta.........	10	2235	40.44	.....	......	17.65	33.45	......
Nepesta to Otero canal.........	8	182	......	5.78	......	11.00	15.24	......
Otero canal Apishapa creek..	7	57	16.90	.....	18.15	....	......	6.43
Apishapa creek to Rocky Ford.	16½	1667	30.55	.....	31.21	.....	32.73	......
Rocky Ford to Ft Lyon canal...	9	749	35.59	.....	22.39	.....	52.20	......
Ft. Lyon canal to La Junta.....	3	88	13.04	.....	8.20	.....	6.77	......
La Junta to Jones ditch...	11	115	10.85	.....	14.76	....	......	4.96
Jones ditch to Las Animas..	9	193	28.51	.....	20.08	.....	39.33	......
Las Animas to Old Ft. Lyon.	6	3509	38.14	.....	13.26	.....	16.46	......
Old Ft. Lyon to Caddoa	11	660	3.63	.....	......	0.16	11.37	......
Caddoa to Amity canal.........	10	445	......	....	......	6.64	......	24.09
Amity to Lamar.	11	256	......	.....	6.68	.....	13.71	......
Lamar to Holly.	30	461	13.21	.....	14.20	.....	45.19	......
Holly to Coolidge, Kan....	7	1171	......	....	......	.....	3.21	......
	215	15960	303.26†	57.36	243.81	51.41	269.66	103.59
			57.36		51.41		103.59	
			245.90†		192.40		166.07	
							55.‡	
							221.	

* Evident error.

† This omits the section from Caddoa to Lamar, lost by the breaking of the meter in slush ice and considers the gain from Orchard Grove to Boone to be that found in 1898.

‡ Estimated gain from Canon City to Bessemer ditch.

J. D. STANNARD, PHOTO.

Fig. 5. FORESTS AND SNOW. Snow Drifts in Green Timber June 21, 1899. Elevation 9600 ft. Looking Northwest.

J. D. STANNARD, PHOTO.

Fig. 6. From same point as Fig. 5. Same date. Looking Southwest into area exposed to sun.

River Flow.

The Poudre river, watering the valley adjacent to Fort Collins and Greeley, is a typical irrigation stream. For fifteen years records have been kept of the discharge at a point about twelve miles from the College with automatic instruments. The watershed above this point exceeds 1,000 square miles. Weekly bulletins have been prepared for the local use of papers in northern Colorado. The quantity given is the amount measured at the canon, and includes an amount not exceeding 150 cubic feet per second diverted from other watersheds. This is not separately considered here. The amount is in cubic feet per second.

Week Ending	1899	1898	Normal.	Week Ending	1899	1898	Normal.
April 18	311	167	149	Aug. 15	640	153	350
" 25	340	181	280	" 22	463	134	329
May 2	356	285	471	" 29	302	121	268
" 9	546	248	636	Sept. 5	355	127	225
" 16	1085	533	938	" 12	254	82	197
" 23	1526	764	1355	" 19	203	58	163
" 30	1791	1126	1750	" 26	130	46	146
June 6	1739	1317	2046	Oct. 3	123	35	142
" 13	2441	1286	2149	" 10	103	50	141
" 20	3114	1567	1938	" 17	133	66	124
" 27	3107	1266	1680	" 24	126	77	115
July 4	2594	790	1378	" 31	240	68	100
" 11	1789	575	1069	Nov. 7	164	......	......
" 18	1407	617	842	" 14	130	......	......
" 25	971	332	642	" 21	95	......	......
Aug. 1	874	231	495	" 28	75	......	......
" 8	845	202	421	Average	860	431	708

Duty of Water.

Measurements were continued on a number of farms, several by automatic recording instruments.

The hay ranch of W. M. Post, and the general farm of J. H. McClelland, have now had the amount of water used by them measured for nine consecutive years. The results show very decided differences from year to year, so much so that it is evident that any conclusion based on the records of anything less than several years is on a very uncertain basis. Canal companies are often suspicious of inquiries of this nature; nevertheless several have cordially furnished their records for use. J. H. Crowley, of Rocky Ford, P. H. Sheridan, Hon. B. F. Rockafellow, and Henry Earle, of Canon City, and W. F. Crowley, of Holly, are among those whose aid has been especially useful. This material will soon be brought into form for publication. A number of diagrams are already prepared.

The investigations on irrigation in the Arkansas Valley have not reached the degree of success hoped for. Mr. R. W. Hawley, who became acquainted with the valley in 1898, was continued in the summer, and made a promising start. An attack of typhoid fever, probably contracted in the exposure in connection with the work, took him from the field in August. As no one else was available with the detailed knowledge of the localities and the investigations, the records for the latter part of the season have lacked the supervision which it was intended to give. The records themselves have not been worked up, and until that is done, full judgment can not be given. Several canal companies have furnished valuable records. Among these records are records on the amount of water used on fields of varying crops, and on orchards, with several places where automatic instruments were used. In some places the records hoped for were interfered with by sediment, which, in the case of the Arkansas river, is sometimes present in large quantities.

The work in meteorology has been continued along the same lines as hitherto. Such observations need to be maintained to give full informa-

tion concerning the conditions surrounding plant growth, and should be rendered accessible to those wanting them. While such material is not desirable for a bulletin for general distribution, it could well be printed as a part of the annual report, and the demands would be met by having some printed separately. There is now considerable data of value obtained from following the same plan for eleven years, and is now worth reducing. When that is done, it will doubtless be desirable to reduce the time given to some of this work.

The snow in the mountains last winter was so exceptional in amount that it gave an unusual opportunity to study the effect of the forest on the preservation of snow. The time chosen was when ground began to show in the forests, in order that photographs would more clearly show the influence to the eye. When our mountain correspondents indicated this period, Mr. Stannard was sent with camera and field developing outfit, and through the guidance of Mr. John Zimmerman, of Home P. O., whose long and intimate acquaintance with the mountains took him to the proper spots without loss of time, some unique photographs were secured. Others were taken in the vicinity of Chamber's lake, through the aid of similar courtesies shown by Mr. John McNabb, superintendent of the "Sky Line" ditch. The photographs show distinctly the important influence the forests exercise in protecting the snow from wind and sun.

Acknowlegements are due to many for favors and courtesies shown. This includes a list too long to give here, and over all parts of Colorado east of the Range.

Respectfully submitted,

L. G. CARPENTER.

Fort Collins, Colorado,

December 6, 1899.

REPORT OF THE RAINBELT SUBSTATION.

(The Name is now changed to Plains Substation.)

To the Executive Committee of the State Board of Agriculture.

GENTLEMEN—I present a report of the work done at the Rainbelt Experiment Station during the year 1899.

The schedule adopted has been carried out, so far as crops were concerned, but we have been unable to carry on investigations concerning the work done by others in the Plains region on account of work at the Station.

We have kept a meteorological record, under the direction of the Meteorologist of the Central Station and have also acted as Volunteer Weather Observer and Crop Reporter for the United States Weather Bureau.

A history of the Station, giving the results of the work from the time of its organization to the present time, has been written and placed in the hands of the Director.

HORTICULTURE.

The trees all grew well. One tree matured a few small apples. Cherry trees bore a small crop. Plums matured no fruit. Gooseberry crop was light.

The seeds of twenty-five varieties of trees were planted. Only a few grew. More may germinate next year.

The following table shows the result of planting trees and plants in the year 1899:

	Number Planted.	Number Living.
Peach trees	19	12
Cherry trees	6	4
Crab apples	10	9
German prunes	5	1
Dwarf pears	6	6
Russian apricots	12	12
Honey locust	1000	438
Ash	1000	484
Wild black cherry	100	17
Elm	100	43
Catalpa	100	90
Russian wild olive	10	10
Raspberries	36	0
Dewberries	100	25
Gooseberries	30	3
Blackberries	150	12
Strawberries	350	20
Currants	10	7
Dwarf Juneberries	12	10

A garden was planted, but nothing did well except beans, peas, radishes and lettuce.

FIELD CROPS.

Five acres were sown to alfalfa. A good stand was obtained upon four acres.

Small grain was a complete failure.

Several varieties of foreign millet were sown. None gave better yields than the ordinary varieties. All foreign varieties ripened seed, but none grew tall, and some of the plants merely stuck their heads out of the ground and went to seed.

Corn made a small crop of fodder, but only two or three bushels of grain per acre.

Potatoes were damaged badly by dry weather and beetles. Only the early varieties produced tubers.

Several varieties of sorghums were tested. Some of them promised well enough to warrant a test on a larger scale. But few of the sorghums

mature seed here. Brown Durra is an early variety of non-saccharine sorghum which has matured a good yield of seed every year it has been tested here.

One variety of cow pea has been grown on the plains until it has become naturalized. It yields a fair crop every year, and has yielded 600 pounds per acre here.

One variety of Navy bean, known as the Tree bean, gives promise of becoming valuable here.

THE "CAMPBELL PROCESS."

Ten acres were devoted to a test of this method of soil culture. Corn, barley and potatoes were planted. A part of each plat, or field, was prepared and cultivated according to instructions given by Mr. Campbell, while the remainder was given good culture merely. No difference can be seen in the results obtained by different methods of culture.

IMPROVEMENTS.

The dwelling has been repainted and storm windows have been put on the north side. An office has been fitted up in the barn and a chimney built in the room.

RECOMMENDATIONS.

1. The crops which have given the best results in small plats should be given field tests.

2. The testing of untried grasses and forage plants should be continued on a small scale.

3. More attention should be given to tree planting.

4. The results obtained by settlers on the plains should be investigated. This information should be published so as to help others who want to live here, or warn those who may not like to live on the plains under the conditions which exist.

5. To enable the superintendent to travel and gather information, the acreage in experi-

mental work proper should be materially reduced. The remainder of the cultivated land might be planted to forage crops which would yield sufficient income to pay for cultivation.

6. Endeavor to induce settlers to co-operate with us in testing forage plants on a large scale.

7. Put more work upon studying the conditions under which crops are produced, and recording observations along that line.

8. Give special attention to ornamental trees, shrubs and flowers best adapted to this region, in order to help people to beautify their homes.

Respectfully submitted,

J. E. PAYNE,
Superintendent.

Cheyenne Wells, Colorado,
December 12, 1899.

REPORT OF THE ARKANSAS VALLEY SUBSTATION.

To the Executive Committee.

GENTLEMEN—Herewith is presented a report, in detail, of the operations of the Arkansas Valley Substation for the year 1899.

The station is located at Rocky Ford, on land belonging to the state, a title being furnished conditional on its use as an experimental farm. The area is 200 acres, 120 of which is leased to F. M. Harsin on shares. The leased portion has consisted, approximately, of 13 acres in corn, 50 acres in cereals, and 50 acres in alfalfa, the balance being taken by roads, railroads, etc. The remaining 80 acres have been under my personal supervision, and the acreage (approximately) may be summarized as, in vegetable and fruit crops, 5 acres; orchards and fruits, 10 acres; grasses, forage and leguminous crops, 15 acres; alfalfa, 15 acres; field crops, 25 acres; waste land and roads, 10 acres.

FEEDING.

The line of feeding inaugurated in the fall of 1898 (the production of "Baby Beef",) was carried through to a successful conclusion. For this purpose 15 head of calves, from 7 to 10 months old, were purchased about the middle of November. Four head had been raised by hand, the others were still running with the cows when purchased. Four head were grade Herefords; one was mostly Texas blood, and the remainder were grade Shorthorns; they were considered a fair average lot of range calves. They were brought to the yards November 14th, and weighed on the 18th, before watering, averaging 342.6 lbs. They were fed on alfalfa hay until December 1st, when they were started on grain by feeding one pound of corn chop per head per day. The grain was gradually increased until, in two weeks, they were receiving three pounds per head daily. About this time we commenced to feed a few sugar beets. They were divided into three pens of five each for a comparison of rations, January 1st. Pen No. 1 was given a ration of three pounds of corn chop and four pounds of sugar beets; pen No. 2, composed of the smaller animals, was given three pounds of corn chop, to which was soon added one pound of whole oats; pen No. 3 was given a ration of three pounds of corn chop and one pound of oats per head daily. In one month this pen was put exclusively on corn. The whole were given the run of a large yard and as much alfalfa hay as they could consume.

The rations were gradually increased until April 1st, when each pen was put on what we considered "full feed." Pen No. 1 received five pounds of chop and eight pounds of sugar beets; pen No. 2, four pounds of corn chop and two pounds of oats; and pen No. 3, seven pounds of corn chop per head daily. These calves were fed an average of 178 days. They were sold to local butchers for $4.60 per cwt., deducting 3 per cent. for shrinkage.

The results for the whole period may be summarized as follows:

		Average Prices.
Hay consumed,	25,705 lbs.	$3.00 per ton.
Chop consumed,	9,370 lbs.	.80 per cwt.
Corn consumed,	979 lbs.	.70 per cwt.
Oats consumed,	1,271 lbs.	1.00 per cwt.
Sugar beets consumed	4,047 lbs.	3.00 per ton.

Average weight when purchased,	342.6 lbs.
" " " sold,	602.7 lbs.
Total gain, (less 3 per cent.)	3,974 lbs.
Number of days fed	178
Average daily gain, (less shrinkage)	1.49 lbs.
Total cost, (15 head at $18.00)	$270.00
Total cost of feed at these prices	$139.14
Total amount sold for	$415.88
Cost of gain per pound at above prices	3½ cts.

GRAINS.

Twenty varieties of fall wheat were tested for growth, production and period of maturity. The principal object was to secure some hardy, productive variety of good quality that would mature before the hot summer weather. Some of the varieties did not prove desirable and were not threshed separately, hence their yields do not appear in the following table.

Name.	*Yield in lbs.*	*Amount sown lbs.*	*Date of ripening.*
Red Mediterranean		1	July 18
Big May		1	July 18
Fultz		1	June 30
Ruby	65	1	July 10
Hunter's Winter	67	1	June 30
Scotch Fife	67	1	June 25
Hedgerow		1	July 5
Defiance	69	1	July 10
Advance		1	" 15
University No. 169	64	1	" 18
Preston		1	" 18
University No. 163	69	1	" 10
Willman's Fife		1	" 20
Bolton's Bluestem	67	1	" 15
Russian No. 10	653	10	" 10
Russian No. 4	326	3	" 15
Russian No. 2		2	" 20
Russian No. 4	357	3	" 15
Red Russian No. 19	1 920	25	" 5

Samples were selected in the field of the most desirable seed for sowing in the fall of 1899. The following were sown under field conditions, in the amounts given, on the 6th and 7th of October 1899, and were looking well when winter came: Red Russian, 190 pounds; Hunter's Winter, 67 pounds; Scotch Fife, 52 pounds; Bolton's Bluestem, 67 pounds; No. 169, 52 pounds; Russian No. 4, 63 pounds; Ruby, 25 pounds; and Russian No. 10, 63 pounds. Seed was furnished us from the Agricultural Section, at Fort Collins, as a part of the test of latitude and altitude upon the gluten content of the wheat.

Four acres of Polish wheat or Mammoth rye were grown, under field conditions, for seed distribution and feeding purposes. It was our aim to introduce this for growing under ditches of scant water supply to supplement corn as a sheep food. It yielded at the rate of 25 pushels per acre.

Hulless barley was grown on slightly less than three acres of land to note its growth and productiveness and for seed distribution. The straw was short and the growth not satisfactory; 55 bushels were threshed and we considered the yield at the rate of 20 bushels per acre.

CORN.

The Iowa Silver Mine, Leaming, White Kansas King and Golden Beauty varieties of corn were grown under field conditions to note their growth, yield, period of maturity and adaptability. By seed selection we are attempting to reduce the ripening period of the Golden Beauty. This is a splendid variety of corn and the results this year show that its ripening period has been so reduced that it will fully mature here. From 4.7 acres we secured 245 bushels of ear corn. The Iowa Silver-Mine and Leaming have not been husked at this writing. From one pound of seed 390 pounds of ear corn were obtained from the Kansas King.

PASTURES.

The testing of grasses and clovers for pasture purposes has been continued. Those showing the best results were placed under field conditions, to demonstrate in a larger way their utility.

About 1½ acres were sown to *Bromus inermis* in the fall of 1898, and a good stand was secured. This was pastured lightly this fall. This grass has has not proven, so far, all that was expected of it. This sowing was made to give further trial before passing judgment.

The Station has demonstrated that Orchard grass thrives well, and in order to place it under practical conditions, considerable sowings of it, both alone and with mixtures, were made. About one acre was sown for pasture; also a plat containing Tall Meadow Oat grass and another containing alfalfa. Perennial Rye grass, Tall Meadow Oat grass and Hairy Vetch were also sown with the view of using them for pasture.

ALFALFA.

Turkestan alfalfa is being tested to note its growth and adaptability and for comparison with the kind commonly grown.

Fall and Spring sowings of alfalfa are being compared and notes are being taken on the effect sub-irrigation and cultivation may have upon seed production.

GREEN FERTILIZERS.

Hairy or Russian Vetch, field pea and cowpea were grown to note their value as green fertilizers. The work this year has consisted of noting their growth and yield and the production of seed for future use. April 1st, 54 pounds of Mummy field pea were put on about ¾ of an acre. They made splendid growth, about 4 feet, and were harvested July 12 for seed. The yield was 9 bushels after considerable loss from storm. The Hairy Vetch, sown in 1898, did not take much growth until the

spring of 1899. On April 27th it was about six inches high. It was allowed to go to seed this year, yielding 65 pounds on 10,270 square feet of land. It ripened the first week in July. This is a valuable bee plant, blooming profusely as it does in early spring.

Four varieties of the Cow pea were grown, namely, Whipporwill, Black, Clay and Blackeye; the last two in small quantities only. Fifty-five pounds of the former were put on about 6-7 of an acre. The yield of straw and grain was 2,800 pounds. Fifty-seven pounds of the Black were put on about ⅞ of an acre. The yield was 2,125 pounds. The Whipporwill is the most desirable because of its upright growth. This plant is valuable for this section, especially for planting late and turning under as a fertilizer.

FORAGE.

The Idaho pea, field pea, Cow pea and Soya bean are being tested as forage and grain crops. Foreseeing the need of a nitrogenous grain for feeding purposes, we hoped to demonstrate the value of their production and the advisability of their more general use. The first mentioned is not quite meeting expectations in the matter of growth. It bears seed profusely, but it is so short of stem that it is difficult to harvest. It yielded 4,000 pounds per acre, straw and grain. Most of it was fed to hogs without threshing, and was relished by them. An epidemic of sickness among the hogs of this vicinity prevented reliable notes on the growth it would produce.

The medium Soya bean was grown. The seed was drilled in May 25, irrigated for germination on the 31st, and again irrigated June 28 and August 23. 155 pounds of grain were taken from 16,600 square feet of land, or at the rate of 400 pounds per acre. It was ripe by September 10; cut with mower and raked with horse.

This plant yields heavily, resists drouth extremely well, and is very highly nitrogenous.

CANTALOUPE.

Different amounts of irrigation were given to three plats of cantaloupe to test the effect on quality and production. The soil was of the same character, the seed was planted at the same time and treated in the same manner for the first month.

One plat received seven irrigations, on June 19, 30, July 10, August 1, 17, 26, and September 4; another three irrigations on June 30, August 1, September 4; and the third one irrigation on July 10, just before a very heavy rain. Each irrigation lasted about six hours.

It is common in this vicinity to irrigate about every eight days, paying but little attention to the needs of the plant. Very heavy rains occurred in July, furnishing all the moisture necessary. There was no appreciable difference in the yield or the quality of the first two plats mentioned. Both the fruit and the vine of the third were smaller and consequently the production less. The quality seemed to be better than the others.

The idea prevails with some that much rainy weather has a tendency to produce a poor quality of melon. Our tests indicate that a too plentiful supply of moisture may deteriorate the melon, but as it is not marked, the loss in quality so much complained of, must be traced to some other cause.

The next experiment we wish to note was a comparison of cantaloupes on alfalfa sod with those grown on a soil cropped in different ways for a few years past. We also wish to note the difference in quality and production of the crop grown on this soil as compared with barnyard manure used in the hill, and bone dust (finely ground bone) also in the hill. The alfalfa was plowed under in the fall and replowed in the spring. On the alfalfa sod the vines were large and rank, the fruit of good size and quality, and production larger. Some hills had as high as eighteen good, merchantable

melons. They also resisted disease much better, hence produced fruit later. The quality, as a general thing, was better. There was no appreciable benefit from the use of the bone. That manured with barnyard manure produced more and better vines and fruit than when no fertilizer was used. Evidently a nitrogenous fertilizer is all that is needed upon these soils for the cantaloupes.

A test was made to note to what extent hot-bed propagation may hasten maturity and how successfully it may be performed.

The seed was put in hot beds April 3d. Some seed was put in cans so arranged that the plants could be taken from them without disturbing the roots. Other seed was put in the hot bed without any support. It was found quite difficult to transplant them when the roots were at all disturbed. Fully 95 per cent of those set out from the cans grew, and about 50 per cent. of those taken from the bed without support.

The first planting in the field was on April 29th, and the next on May 10th. The first ripe melon was taken from the transplanted vines August 17th, only one day ahead of the plants grown on alfalfa and manure, and only four days ahead of those grown with no fertilizer. They ripened in quantity, however, faster, and for the next ten days gave more ripe melons than any other planting.

Anticipating that the leaf blight that had been affecting the cantaloupe for two or three seasons previous to 1899 would gradually increase until it endangered this crop, we secured some seed from melons affected in 1898, to plant in 1899, to note whether the disease was communicated to the plant from the seed. The seed was planted separately and on land that had not produced melons for some years at least. The trial did not show that the disease is communicated to the plant by the seed. A striking similarity is shown between the product and the parent crop. To further note this and to improve the quality and shape by selec-

tion, for the purpose of securing high-class seed for distribution to maintain a high quality of this product three grades of seed were made this year for use of another season.

The only insect troubling the cantaloupe was a few small, black flea beetles. These appeared when the plant had but two leaves. A spraying with Paris green and lime (1 oz. of the green to 10 gallons of water) was sufficient to reduce their injury.

During the season much valuable work was done combatting the leaf blight (*Macrosporium cucumeris* of the cantaloupe. This disease was prevalent and seriously affected the crop, especially in the vicinity of Rocky Ford. This disease appeared seriously in 1898 in some fields but this year it spread rapidly and reduced the product on many fields to a very small amount. The quality of the cantaloupe was greatly impaired wherever this trouble was of a serious nature.

We began early to spray the plants grown from seed taken from blighted melons in 1898. The first spraying was done June 22d, at which time there was no appearance of blight, but one-half of the vines were left unsprayed as checks. They were again sprayed June 30th when we noted "something on the leaves which appears like blight." At this time the vines were just beginning to run well. Previous to the 19th of June the weather had been very dry. July 7th we had .44 in. of rain, and during the month 7 inches fell, most of it in the week commencing the 13th.

We did not spray again until July 22d, at which time the blight was strongly in evidence. July 31 we sprayed the new growth. August 11 we sprayed what new growth had been made. The sprayings made after the 22d of July were a great benefit. The vines held up fairly well and the fruit was of good quality, while that of the unsprayed vines ripened prematurely. The sprayed vines were in good condition from two to three

weeks after the others had succumbed to the disease. This disease spread so rapidly, and the question was of so much importance that we inaugurated other experiments, in the latter part of July, on a much more extensive scale. Spraying was done with Bordeaux mixture and with ammoniacal copper carbonate, both upon the Station and upon Mr. I. D. Hale's place. We also used the Bordeaux mixture upon about an eighth of an acre of cantaloupes belonging to G. W. Swink, and on about one acre belonging to I. D. Hale. These were given but one spraying. To further test the Bordeaux mixture, 1¾ acres were sprayed once on Mr. Fenlason's place. This was done August 22 and 23. The vines were large and completely covered the ground. The blight was showing quite extensively. The principal object was to obtain the cost of spraying. These tests confirmed the conclusions formerly drawn, and the many people who saw the effect of the spraying were convinced of its benefits.

POTATO.

This section of the state is not the habitat of the potato. Much experimental and field work has been done by the Station with this vegetable.

Our work embraced some investigations bearing upon soil treatment and general cultural requirements, hoping at least to establish some general principles that would enable the farmer to produce potatoes in sufficient quantity for domestic use.

Three plantings were made on different dates on alfalfa sod, namely, May 11, 26, June 13. The yields were 570 pounds from the first planting; 420 pounds from the second; and 138 pounds from the third from the same area for each. The first planting was much the best: the last was small and of little value.

A test was made to find the effects of different amounts of irrigation. Eighteen rows of Mammoth

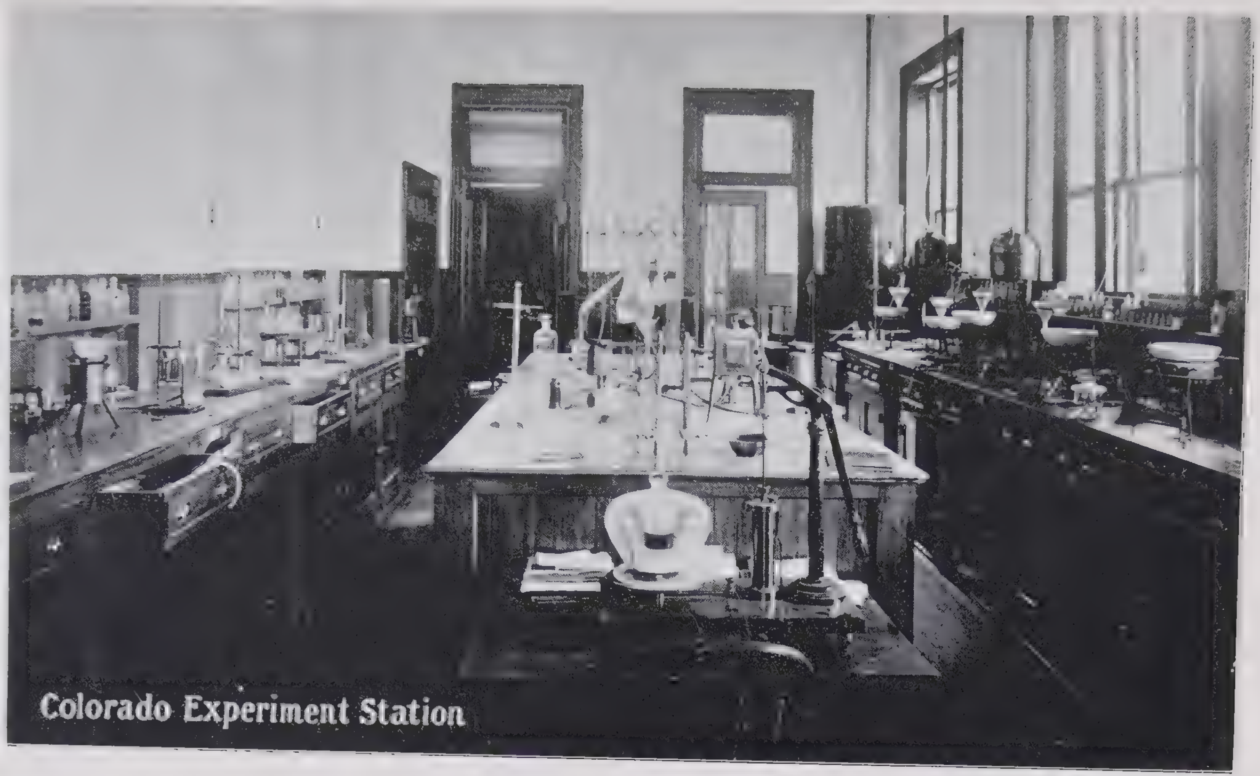


Fig. 7. Chemical Laboratory.

Pearl and 14 rows of Rose Prolific each 217 feet long were employed. The former was divided into two plats of nine rows each, and the latter into two of seven rows each. It was intended to irrigate one plat of each kind a sufficient number of times to keep the plants growing thriftily. The other plats were to remain without water until such time as they were actually in need of it.

The idea prevails that irrigation causes the rank growth of vines at the expense of the tuber growth. The following table gives the amounts of irrigation and the results:

Name.	*No. of rows.*	*Dates of Irrigation.*	*Yield in Pounds.*
Mammoth Pearl	9	July 1, 31, Aug. 20, Sept. 5	405
Mammoth Pearl	9	Aug. 4, 20, Sept. 5	145
Rose Prolific	7	July 2, Aug. 18, Sept. 4	545
Rose Prolific	7	Aug. 3, 18, Sept. 4	305

Planting was done May 30 and irrigation employed to germinate the seed. The cultivation of each plat was the same.

CELERY.

Owing to the demand for information upon the growth of celery, some work has been done to note the character of soil and the methods of culture needed for its production.

To do this we have compared the work of the Station with that of outside parties. Two things have been demonstrated; namely, that the seed must be sown in open field and only the large and thrifty plants used for transplanting; and second, that blanching by earth must be employed to secure a quality at all desirable.

SUGAR BEET.

Three lines of work have been employed with the sugar beet; viz: in a small way to test what effect the different dates of planting may have upon the germination, yield and sugar content of the beet; the production of seed (from beets tested

by the specific gravity method for high saccharine quality) for the improvement of the sugar content; and one acre, under field conditions, to note the general requirements and the cost of production.

Four rows, each twenty feet long, were planted April 4 and 17, and May 2, 16 and 21. On May 2, two plats of four rows each were planted so two rows were eleven inches apart, then a space of 27 inches and then 11 inches between rows again. The weather was such that germination was very poor, and not before May 16 were we able to secure a fairly good stand.

The beets were dug October 21 and sent to Grand Junction for analysis the 23d. The table gives results:

No.	*Time of planting.*	*Yields in lbs.*	*Per cent. total solids.*	*Per cent. sugar in juice.*	*Per cent. purity.*
1	April 4	123	19.42	16.10	83
2	April 17	112	18.09	14.95	83 2
3	May 2 (close)	110½	20.20	16.90	83.7
4	May 2 (wide)	112	17.21	13 80	80.2
5	May 2 (close)	97½	17.71	14 65	80
6	May 2 (wide)	125½	18.18	14.65	80 6
7	May 16	191½	18.42	15 55	84.5
8	May 31	131½	18.32	14.80	86.8

The sugar content of about 110 beets tested from 17 to 23 per cent. by the specific gravity test. A considerable quantity of seed was secured which will be planted to test to what extent the sugar content may be improved. Some of these beets were planted between rows of corn and in the protection of orchard trees. The results showed no benefit. There was no destruction (from wind) of the seeds where grown in the open. The above work was done in connection with Professor W. W. Cooke.

To test the cost of production 8½ pounds of seed were put in with grain drill May 4. The land was in splendid condition when the planting was done, but the cold, dry weather following pre-

vented germination. Accordingly, on June 1, the ground was well harrowed with an Acme harrow and 6½ pounds of seed again drilled in. About 50 per cent. of a full stand was secured from the planting. An account was kept of the number of hours employed in the production of the crop. The results are as follows:

Plowing, harrowing, etc., 11½ hours, at 30c	$3.45
Furrowing and cultivating, 23 hours, at 25c	5.75
Seeding, 3 hours, at 30c	90
Hoeing and thinning, 63 hours, at 15c	9.45
Irrigation, 26 hours, at 15c	3.90
Plowing out at harvest, 11½ hours, at 30c	3.45
Topping and pulling, 42½ hours, at 15c	6.37
Total cost	$33.27
Yield, 10 8 tons at $3.00	$32.40

To the above must be added the cost of seed; but on the other hand we must consider that the land is well plowed and an allowance for this should be deducted.

These beets analyzed on the 23d of October: Total solids, 17.55 per cent; sugar in juice, 14.75 per cent; purity, 84.1 per cent. These results were obtained under the most adverse circumstances. The last seeding was too light, but no more seed was available.

BEANS.

Spraying and cultural work has been carried on with the bean, looking to the control of a blight which affects it. Spraying the vines with Bordeaux mixture has given no beneficial results.

Plantings were made May 17 and June 20 to note whether time of planting and maturity has any effect on the occurrence of the disease. The first planting matured August 12, the second by September 13. Both plantings were badly blighted, but the difference, if any, was in favor of the late planting. We anticipated doing some work for the control of the bean anthracnose which was prevalent in 1898, but it did not appear in 1899.

ORCHARD.

The hail storm of June 6, 1899, together with the severe winter following, destroyed nearly the whole of the orchard trees set in 1896, and those reset in the spring of 1898. This is what has been termed the young orchard. The most of the land was reset last spring with 28 varieties of apples, 15 of cherry, 21 of plum, 25 of peach and 16 of pear, besides the following kinds of nuts: butternut, French walnut, Japanese walnut, shellbark hickory, filbert, pecan, sweet chestnut, English filbert and almond.

The number of trees set is as follows: Apples, 75; nuts, 40; cherries, 31; plums and prunes, 45; peach, 50; nectarines, 4; pear, 42; of which 10 apples, 23 nuts, 18 cherries, 11 plums, 11 peaches, 1 pear and 1 nectarine failed to grow.

The large loss of cherries was mostly due to stock injured by the severe winter.

Some varieties in the old orchard have been cut out and many more are in such condition that we will cut them down. The first variety to blight was the Wagner; this was followed by the Mann, Peters, Smith's Cider, Baldwin and Delaware Red, The Clapp's Favorite, Flemish Beauty and Keiffer pears have died. The Longworth still survives, but is not healthy.

Ground bone and wood ashes were applied to the roots of some bearing apple trees to note any effect upon their health, growth and productiveness. Owing to a late frost destroying the bloom, there were but a few scattering apples.

From 12 to 25 plants each of seven new varieties of strawberries were set out this spring, making 24 varieties upon the Station. Seventeen of these varieties were reset from an old bed in the spring of 1898. The hailstorm of June 6 destroyed many plants and so weakened the others that it has taken most of this season for the plants to establish themselves in a healthy condition.

The Strawberry leaf-roller has become quite

troublesome. Burning the vines, over which a light coating of straw had been placed, has been done both fall and spring with beneficial results. If this method is pursued, no doubt this insect can be exterminated.

There is considerable demand for information in regard to varieties of small fruits which will succeed in this section. About one dozen plants of each of the following varieties of berries and one-half dozen of the grapes, besides three plants of the Campbell Early grape were set to supply information along this line:

Blackberries.	*Red Raspberries.*	*Black Raspberries.*	*Foreign Grapes.*
Western Triumph,	Miller Red,	Eureka.	Muscat,
Taylor Prolific,	London,	Gregg,	Ladyfinger,
	Cuthbert,	Palmer,	Black Hamburg,
	Columbian,	Kansas,	Emperor,
			Cornichon,
			Flame Tokay,
			Thompson Seedless.

The weather was very dry and cold after the above were set, and many plants failed to grow. It will take another season to tell to what extent they did succeed. The winter of 1898–1899 killed to the ground all varieties of grapes upon the Station except covered. The list of grapes includes Moore's Early, Lady Washington, Empire State, Worden, Duchess, Concord, Pocklington, Lady, Niagara, Brighton, Delaware, Martha, Woodcraft Red, Catawba and Iona.

The plums fruited but very little this year, the severe winter killing the buds. One tree of Forest Garden, one of De Soto, and two unknown trees were well loaded with fruit. There were a few plums on the west and south sides of the Chickasaw.

Observations have been taken upon some troubles affecting the tomato crop, with the intention of formulating some experiments for their control. Chief among these troubles is a blight of the vines, a rot of the fruit, and a failure of the vine to produce fruit.

ENTOMOLOGY.

In connection with Professor Gillette, some work was done in the orchard of J. H. Crowley, bearing upon the codling moth. It consisted of covering eight trees with netting, to study the efficacy of spraying and to what extent each brood affects the apples. The results seem to show that we have but two broods of the moth, and that the moth ceases transforming about the 20th of August.

METEOROLOGY.

The meteorological records include the following: temperature, maximum and minimum; psychrometer; wet and dry bulb at 7 a. m. and 7 p. m; precipitation; sunshine; wind; frosts; dews; and other phenomena. Reports have been sent monthly to the section at Fort Collins and duplicate reports to the Weather Bureau. The weather of the past season has been characterized by a very cold, windy, dry, spring, followed by heavy rains in July and August, with late and pleasant fall.

We fail to see any beneficial results from the application of gypsum in 1898. All that such a soil needed was proper cultivation and irrigation.

In addition to the experimental work proper, enumerated above, 7 acres of oats, yielding 297 bushels, were grown. Three crops of alfalfa were harvested from 11 acres of land, the yield being estimated at 40 tons. About 60 pounds of cantaloupe seed were saved besides that selected for experimental purposes. Thirty-five crates and five baskets of cantaloupes were sold.

The returns from the leased land have been 85 bushels of corn, (estimated), 60 tons of hay (measured), and 335 bushels of grain.

Respectfully submitted,

H. H. GRIFFIN,

Superintendent.

Rocky Ford, Colorado,

November, 30, 1899.

RECORD OF SIX YEARS WORK AT THE PLAINS SUBSTATION.

J. E. Payne, Superintendent.

Note by the Director:

The Rainbelt Station was established in accordance with the act of the legislature. It is located near Cheyenne Wells, certain so-called wells having existed near the old Overland trail. Subsequently artesian water was sought by the government, and several wells have been put down to considerable depth, the only water found being within a few hundred feet of the surface.

This station has the characteristic climate of the Great Plains —hot summer days, with heavy drying winds, and occasional heavy downpours of rain. The region is entirely given to range stock. The early trials of the settlers at farming have been failures. Now a few, who are principally interested in the range industry, are again making trial and with some degree of success. The investigations of the Station have followed the plans of the superintendent, and have been carried on under discouraging conditions. The work has been largely negative in results. The unsuccessful as well as the successful trials are here recorded so as to be accessible to those who may be interested in the Plains.

In general the available supply of moisture has not been sufficient to tide the shallow-rooted crops over the dry periods. A plan of investigation somewhat different will be followed in 1900.

Until 1870 but very little country west of the one hundredth meridian was settled. But the pressure of population in the eastern states induced people to look for homes in the "Great Plains" region. Gradually, the tide of immigration, led on by land agents who advertised the country, flowed

westward until all the "blue-stem" region was settled, and much of the "short-grass country" was occupied by enthusiastic home-seekers.

By the year 1888 a considerable part of eastern Colorado was in possession of people who were determined to make the desert "blossom as the rose." One or two years of well distributed rainfall encouraged settlers. These were followed by several years unfavorable to farm crops. These, coupled with an imperfect knowledge of crops adapted to the country, soon caused an exodus of the enthusiasts. Only those who depended upon stock-raising for their living stayed in the country.

Land agents and railroad companies held the theory that eastern Colorado and western Kansas could be a farming country without irrigation if the conditions prevailing could be thoroughly understood.

Acting upon this theory, an agitation was begun for the establishment of an Agricultural Experiment Station in what was called "the Rainbelt." This resulted in the passage of a bill appropriating twenty-five hundred dollars ($2,500) from the Internal Improvement fund for the equipment of such a station to be located in Cheyenne county. This law went into effect too late in 1893 for any farming to be done that year.

A committee from The State Board of Agriculture, consisting of Messrs. Emigh, McClelland, and Kellogg, selected the northeast quarter of section 29, township 14 south, range 44 west (the same being railroad land), as the site of the Station. This land was deeded to The State Board of Agriculture on condition that it be used forever as an agricultural experiment station.

After the land was acquired, the northeast forty acres was broken during the winter of 1893-94. Contracts for a dwelling house and a barn were also let. The house was ready for use in April, 1894, and the barn a little later.

The question of water supply came up early

in the history of the Station. The school district in which the Station was located offered to supply water for the domestic use of the Station. To make the water furnished by the school district available, 3,000 feet of pipe was laid. Two T's were put in. One is twelve and a half rods north of the north fence of the Station, and the other opposite the mixing pits of the brickyard, which are about fifty rods north of the north fence of the Station. The latter was afterwords fitted with a valve, and a pipe was attached for supplying water to the brickyard. The one nearest the fence was plugged.

Water was supplied according to contract by the school district until January 1, 1899, when the Union Pacific railroad company leased the well and assumed the obligations of the school district in this particular.

April 1, 1894, Mr. J. B. Robertson, a practical farmer of considerable experience, took charge of the Station as Superintendent.

The season of 1894 was unfavorable for crops all over the plains region. The crop on the Station farm, being on sod, fared badly. Only a few hundred pounds of fodder per acre was cut from the plats planted to corn, Kaffir corn, and saccharine sorghums. No grain of any kind was produced. A few trees were set out near the house, and ground was broken in October for an orchard.

In 1895 all fodder crops produced good yields. Small grain was a failure on account of a severe hailstorm June 20th. The same storm cut corn down so badly that but little mature seed was produced. Two acres were planted to fruit and forest trees.

April 1, 1896, Mr. Robertson was succeeded by Mr. J. E. Payne. The schedule of work for the year had been already adopted, and was carried out as planned. No trees were planted. Small grain was a failure. No grain was produced except by three varieties of Kaffir corn. The study of soils was pursued as circumstances would per-

mit. An implement shed was built this year; also a sod wall wind break. A moderate yield of fodder was produced.

The year 1897 was quite favorable to the production of fodder crops. This year, the main work of the Station was put upon a test of varieties. Several hundred varieties of grains and grasses were planted, but none proved to be better than the standard varieties grown in western Kansas. Three thousand seedling Russian mulberries were set out. Nine hundred cuttings of Russian Artemisia were planted. The Russian mulberries are now stout shrubs which winterkill badly. Only three Artemisia shrubs are now alive. The vacancies in the orchard were filled with trees from Fort Collins.

In 1898 some small grains made moderate yields. Corn yielded about fifteen bushels per acre. Only a few varieties were tested. No trees were set. Fodder crops which were cultivated made good yields, but sorghum sown made practically nothing.

The year 1899 proved to be one of the most unfavorable in the history of the Station. Twenty-three hundred forest trees were set. Seven hundred plants of various small fruits were set out. A few standard fruit trees were planted. A large number of varieties of seeds of foreign plants were sent here by the U. S. Department of Agriculture. None tested have proved superior to varieties already in cultivation on the plains.

The following maps give some idea of the location of the trees and buildings, and also of the cropping of the cultivated land since it was first broken:

Plate I	shows the	location of crops	in	1895, so far as known.
Plate II	"	"	"	1896,
Plate III	"	"	"	1897.
Plate IV	"	"	"	1898.
Plate V	"	"	"	1899.

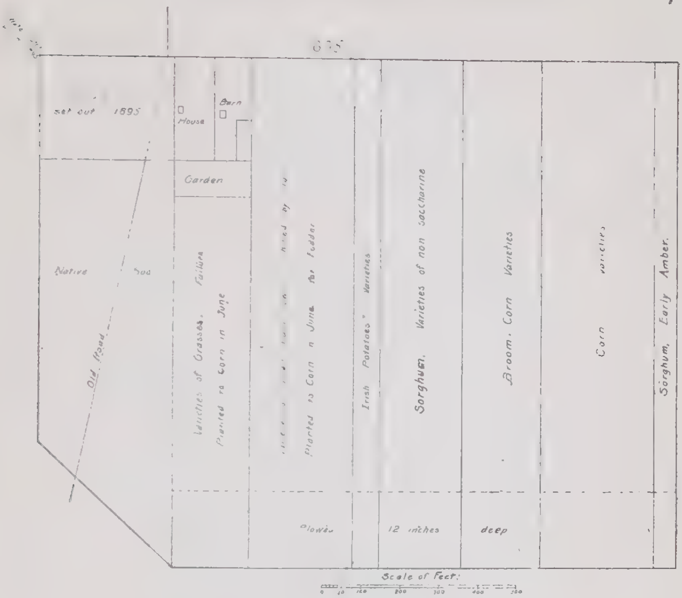


PLATE I.

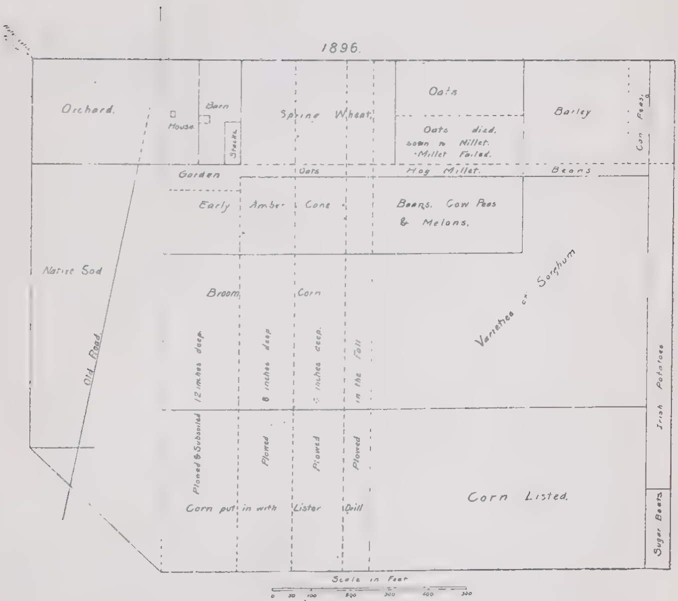


PLATE II.

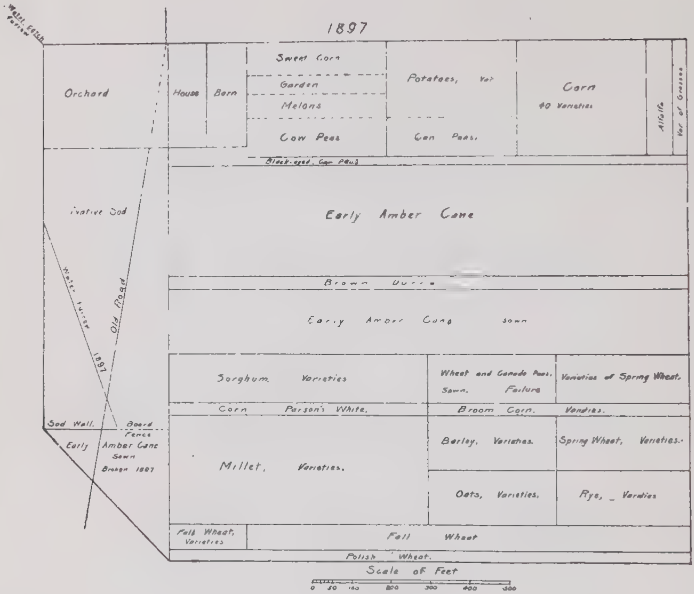


PLATE III.

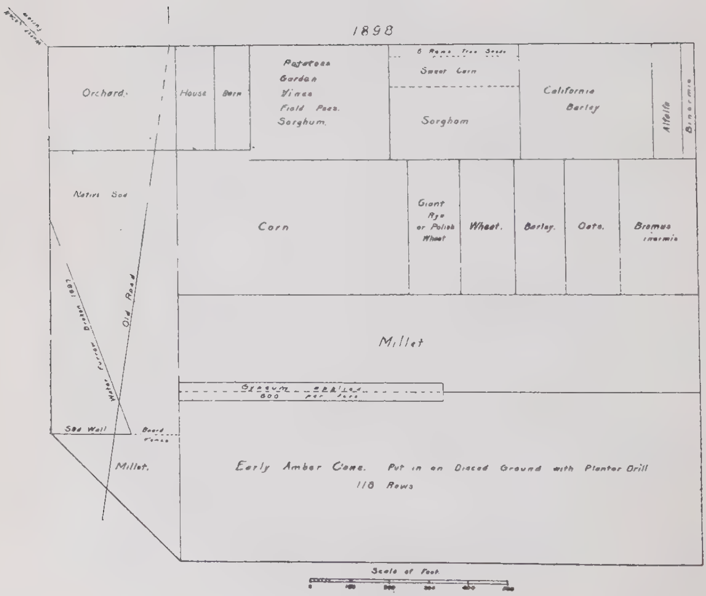


PLATE IV.

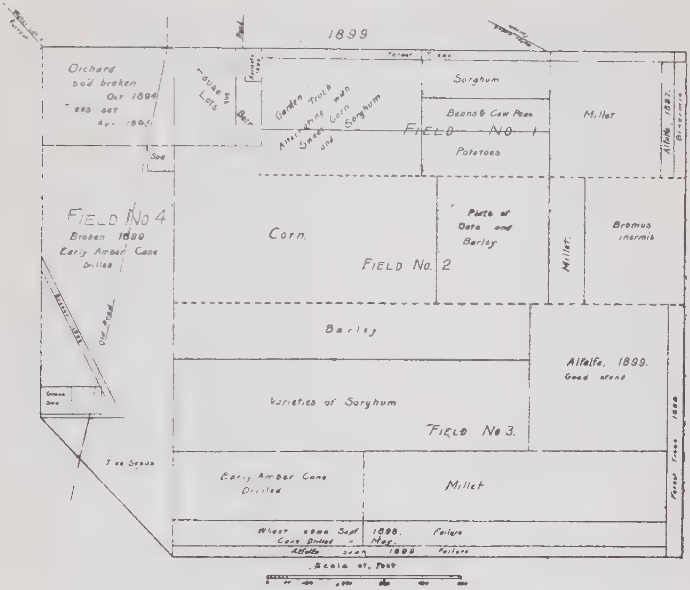


PLATE V.

The following table shows the precipitation at this Station from June 1st, 1894, until Nov. 24th, 1899. The table given in the report for 1898 is incorrect in several cases.

MONTHS	1894	1895	1896	1897	1898	1899	Means
	Inches	Inches	Inches	Inches	Inches	Inches	Inches
January	....	.67	.45	.26	.03	.47	.38
February	....	.27	Tr	.10	.00	.36	.15
March	....	.16	.71	1.58	.61	.39	.69
April	....	1.67	3.41	1.20	1.10	.03	1.48
May	....	1.49	2.28	1.44	5.56	2.88	2.72
June	.48	3.00	3.03	2.22	3.95	1.89	2.43
July	1.99	6.38	2.27	4.19	2.09	3.67	3.43
August	1.03	1.22	3.07	3.24	1.33	.55	1.74
September	.14	Tr	.84	.92	2.00	.78	.78
October	.14	.21	.78	2.73	.48	Tr	.72
November	T	.30	T	.10	.50	2.49	.56
December	.55	.42	.60	.20	.48	0.55	.47
Total	—	15.79	17.44	18.18	18.13	14.06	15.55

The following tables summarize the tests of the different crops and the results. Practically the same methods of culture have been practiced in variety tests from the time the work began until the present time.

BARLEY.

1894—Only one variety, the California, was sown on May 2. Failure.

1895—Three varieties were sown, the California and Mansury, on April 8, and the Black Hulless, on May 6. All failed.

1896—Black Hulless, Mansury and Highland Chief were sown April 20. All failed.

1898—Nineteen varieties were sown. Most produced only seed. Some gave a small yield which is indicated in the figures after the names of the varieties. All were sown April 10.

	Bu.		*Bu.*		*Bu.*
Black Hulless....		Mansury	2.2	Highland Chief...	
White Hulless...		New Beardless...		Surprise..........	
Odessa...........	2.8	Trooper		Vanguard	1.7
Nugent	1.6	Royal		Emerson	
Sudney		French Chevalier		Manhattan	
Nepaul		Silver King......	1.8	Success..........	3.3
		Ideal............			

1898—Two varieties were sown, the California, April 30, which yielded 18 bushels per acre; and the Black Hulless, sown on April 28, yielded 21.6 bushels on packed ground, and 20.2 on unpacked ground.

1899—Only one variety, the White Hulless was sown April 6. Failure.

RYE.

1894—None sown.

1895—Spring rye, sown April 8. Failure.

1896—Colorado Giant Spring rye, sown April 24, and Large Pennsylvania White, sown September 28. Both yielded seed.

1897—Four varieties were sown in April, and none in October. Prolific Spring and

St. John's, sown April 5, yielded seed only. Colorado Giant Spring, sown April 25, yielded 3.4 bushels per acre. Winter rye, sown October 13, was a failure.

1898—Colorado Giant Spring rye, sown April 27, yielded 5.3 bushels on packed and 4.1 bushels on unpacked ground per acre.

1899—None sown.

OATS.

1894—Three varieties were tried. Excelsior was sown April 7; White Russian and White oats May 2 and 3. Failure on account of winds and grasshoppers.

1895—Excelsior, sown April 7, was cut for hay. Yellow French, sown April 18, was destroyed by hail June 20.

1896—Twelve varieties were sown. Two, the Excelsior and Black Russian, were sown April 9; the remainder April 23. The Excelsior was an entire failure, having been blown out. The others produced seed only.

Black Russian,	White Russian,	Belgian,
Golden Sheaf.	Superior Scotch,	Burt's Extra Early Rust Proof,
Red Georgia,	Clydesdale,	Red Rust Proof,
New Welcome,	Nebraska White,	American White.

1897—The following thirty-one varieties were sown April 9. In most cases seed only was produced. The figures following the names indicate the number of bushels per acre where the yield was greater:

Excelsior,		Black Russian,	5.6
Golden Sheaf,		Superior Scotch,	
Burt's Extra Early Rust Proof,	2.0	Red Georgia,	3.7
Clydesdale,		Red Rust Proof,	
New Welcome,		American White,	
Race Horse,		Badger Queen,	
Scotch,		Hazlett's Seizure,	
Scottish Chief,		Imported Irish,	
Rosedale,		Victoria Price.	
White Wonder,		Welcome,	
Poland,		Banner,	
Prize Cluster,		Mennonite,	
Great Northern,		Gold Mine,	
White Maine.		White Bonanza,	
Mexican Gray,		Mortgage Lifter,	3.3
Silver Mine,		New Zealand,	
Negro Wonder,		Lincoln,	
White Schoenen,		Winter Oats,	

1898—Two varieties: the Russian, sown April 28 on packed ground, yielded 20.5 bushels; on unpacked ground, 28.5, Winter Oats, sown October 1, proved a failure.

1899—Seven varieties were sown on April 8. All proved a failure.

Black Russian,	Red Rust Proof,
American White,	New Zealand,
Negro Wonder,	Lincoln,
White Schoenen.	

WINTER WHEAT.

No Winter wheat was tried in 1894 or 1895, 1897 or 1899.

1896—Thirty-five varieties were sown. The first ten named were sown September 23; the next nine, September 28; the remainder September 30, except the last two, which were sown October 1. Where figures are given after the names the yield per acre is indicated.

Buckeye		Seneca Chief	
Turkey	2.1	Red May	
Tasmanian Red	4.0	Zimmerman	3.9
Theiss	1.8	Deitz	1.1
Currell		Fulcaster	1.6
Golden Cross	1.7	Gold Coin	
Poole	1.7	Jones' Winter Fife	2.2
Early Red Clawson	1.1	Improved Fultz	1.4
Forty-fold		Rochester Red	2.3
Prize Taker		YX (Russian)	
Red Winter		Genealogique Red	
Bearded Winter		Amautka	
Red Girka		De Thiess	
Compound		Belokoloska	
Genealogique White		Winter Girka	
Buda Pesth (Austria)	1.2	Turkey (in row—Kansas)	4.2
Mediterranean (in row—Kansas)	1.6	Turkey (Kansas) broad cast	4.6
		Mediterranean " "	4.2

1898—One variety, the Golden Cross, was sown October 10. Failure.

Fig. 8 Room for Nitrogen Determination.

SPRING WHEAT.

1894—Three varieties, Blount's No. 10, No. 16, and Defiance, were sown May 3. Failure.

1895—Four varieties, Velvet Chaff, Saskatchewan Fife, Marvel and Polish, were sown March 18, and Defiance, April 17. All proved a failure.

1896—Blount's No. 16 and Defiance were sown April 21, Polish, April 24. Seed was produced.

1897—Twenty-nine varieties were sown; the first three on April 5, the remainder April 10. The figures after the names give the number of bushels per acre:

Blount's No. 16	2.8	Defiance	
Polish	3.4	Velvet Chaff	
Saskatchewan Fife	2.0	Spiltz	
Club	2.3	Colorado	
Sutherlin	2.8	Ladoga	2.2
Alpha	1.8	Red Fife	1.8
Advance	1.7	White Fife	1.3
Rideau	1.8	Old Red River	1.8
Admiral	2.0	Crown	1.7
Stanley	1.8	White Connel	1.6
Preston	.9	Pringle's Champlain	1.8
Blue Stem	1.6	Pillsbury	1.8
Hayne's Pedigree Blue Stem		Pedigree Blue Stem	
Assiniboia		Okanagan Velvet Chaff	
		Spring Girka	

1898—Only two varieties were sown, April 26 and 27. Blount's No. 16 yielded 3.8 bushels on packed ground; 4.6 on unpacked. Defiance yielded 5.1 bushels on packed ground, and 4.6 on unpacked ground.

1899—No varieties tried.

BROOM CORN.

1894—Four varieties, California Golden, New Japanese, Dwarf and Imperial Evergreen, were sown May 10. Each produced from 400 to 450 pounds of fodder.

1895—Three varieties, The Missouri Evergreen, Tennesee, California Golden, were sown

May 23. About 800 pounds of good brush were obtained from the low ground.

1896—The same three varieties were sown May 28. A little good brush was obtained. All cut for fodder.

1897—Eight varieties were sown May 18. The Missouri Evergreen and Tennessee produced good brush. The Dwarf was a failure. The Wisconsin, Early Japanese, Australian, Wilson's Improved Evergreen and Dwarf Emerald produced medium brush of poor quality.

1898—No broom corn was planted. A good yield of brush was obtained by those who did plant.

1899—No broom corn planted in Cheyenne county.

MISCELLANEOUS FORAGE PLANTS.

1894—None tried.

1895—*Avena flavescens*, *Holcus lanatus*, and *Bromus inermis*, sown March 22. All blown out. *Bromus uniloides*, *Panicum virgatum*, and *Sergula maxima*, sown May 6. Failure. Timothy and meadow fescue, sown May 13, did not grow. *Bromus inermis*, sown June 6, was taken by grasshoppers. Redtop (*Agrostis vulgaris*), sown June 28. Failure.

1896—*Bromus inermis*, sown May 2, did not grow.

1897—Thirty-four varieties were sown May 2. Johnson grass was the only one that made a good stand. The others did not grow. The seed of all the other varieties, except the first five, came from Queensland, Australia.

Bromus inermis,
Lolium tenue,
Lolium Italicum,
Arrhenatherum avernaceum, (Tall Meadow Oat),
Esparsette,
Panicum simialatum,
Panicum parviflorum,
Panicum Indicum,
Panicum Crus-galli,
Bromus arenarius,
Atriplex vesicaria,
Antriplex mummularia,
Sporobolus Virginicus,
Tragus racemosa,
Perotis rara.
Pappophorum Nigricans.
Dyeuxia Forsteri,
Paspalum Galmarra,
Eragrostis Brownii,

Panicum Prenticeanum,	*Anthistiri ciliata,*
Andropogon erianthoides,	*Anthistiri avenaceae,*
Andropogon schœnanthus,	*Leersia hexandra,*
Andropogon pertusus.	*Astrebla pectinata,*
Chrysopogon gryllus,	*Setaria macrostachya,*
Chrysopogon parviflorus,	*Setaria glauca,*
Leptochloa Chinensis,	*Sorghum halpense* (Johnson grass).
Pollinaria fulva,	

1898—Johnson grass was winter killed. *Bromus inermis* was sown April 30, and made a good stand.

1899—Nearly all the *Bromus inermis* sown in 1898 was killed by the dry weather; also that sown April 20 did not live through the dry weather. *Agropyron cristatum*, from Russia, sown April 20, proved a failure.

POTATOES.

1894—Four varieties, the Chicago Market, Negro, Mountain Sprout and Early Rose, were planted May 5. All proved a failure on account of drouth.

1895—A better result was secured. Vick's Perfection, planted April 20, yielded 16.5 bushels; Mammoth Pearl, 32.5 bushels; Mammoth Prolific, 36 bushels; and Late Ohio, 27.5 bushels. These were planted May 20.

1896—The Early Ohio, Early Six Weeks, Early Kansas, King of the Earliest, were planted April 30. Vick's Perfection, Mammoth Pearl, Mammoth Prolific and Late Ohio were planted May 22. Potato beetles took all except a small plat of Mammoth Pearl, which yielded 80 bushels.

1897—Forty varieties were planted May 12 and 13. The figures after the names give the number of bushels per acre obtained:

1.	Early Rose	28.0	2.	Early Ohio	45.6
3.	Early 6-weeks	46.5	4.	Early Kansas	8.0
5.	Early Thoroughbred	48.0	6.	Irish Daisy	38.0
7.	Carman No. 1	48.9	8.	Early Vaughan	40.5
9.	Victor Rose	41.0	10.	Beauty of Beauties	57.0
11.	Carman No. 3	59.0	12.	Snowflake	56.8
13.	Crown Jewel	41.5	14.	Early Fortune	62.3

15. Early Minnesota.......46 2	16. Early Montana........36.4
17. King of the Earliest....20.6	18. Ajax..................30.4
19. Maggie Murphy........32.5	20. Early Freeman........21.7
21. Boston Red............38.3	22. Bliss Triumph, or Stray Beauty..............39.0
23. American Wonder......26.9	
24. Harvest King..........45.0	25. World's Fair...........22.3
26. Champion of the World.24.7	27. Ironclad...............32.3
28. Good Times............41.3	29. 100-Fold...............34.7
30. Early Beauty of Hebron................19.8	31. New York Early Rose..38.2
	32. Peerless...............16.1
33. Lightning Express.....28.0	34. Extra Early Ohio......36.5
35. Quick Crop............23.5	36 Acme..................28.5
37. White Star............20.7	38. Ohio Junior............35.0
39. Burbank's Seedling.....22.0	40. Burbank...............42.0

The first sixteen varieties mentioned in the list for 1897 were sown in 1898

1898—The potatoes were all damaged by beetles. Only a few of the early varieties produced any tubers.

1899—Four varieties were sown April 29. The Early Beauty of Hebron and Carman Nos. 1 and 3 were failures. The Early Ohio yielded 17 bushels per acre. All were damaged by beetles. The Rural, Planted July 13, was taken by beetles.

SWEET CORN.

1894—Stowell's Evergreen and Early Crosby were planted May 15. No record. Said to be an entire failure.

1895—Stowell's Evergreen planted May 24. No record. Said to be a failure on account of hail storm of June 20.

1896—Stowell's Evergreen, White Cob Cory, Black Mexican and Country Gentleman planted May 2. All produced a few ears.

1897—Eighteen varieties were planted May 11. All gave good yields. Those marked * did especially well. The date after the name of the variety gives the time when edible ears were obtained.

White Cob Cory.........July 26	Black Mexican..........Aug. 5
* Country Gentleman....Aug. 21	* Egyptian.............Aug. 19
Early Minnesota.........Aug. 11	Perry's Hybrid..........Aug. 5
* First of All............July 26	* None Such............Aug. 19
Shaker's Early Concord..Aug. 5	* Early Bonanza........Aug. 14
Improved Ruby.........Aug. 21	Northern Pedigree......Aug. 5
First of All............Aug. 4	Early Crosby............July 26
Early Adams............July 26	Early Marblehead.......July 26
Moore's Early Concord...Aug. 9	

1898—The Mammoth and the first thirteen varieties of those given in 1897 were planted May 18. Drouth affected affected all varieties badly. None produced large yields. The dates when edible corn was found were about the same as for the same varieties in 1896. The Mammoth gave edible ears August 20.

1899—Egyptian, First of All, None Such, Mammoth, Everbearing and Metropolitan were planted May 17. The season was very unfavorable. But few edible ears were produced by any variety. The location of the plats with regard to the amount of water they obtained, seemed to influence the yield more than the variety planted.

GARDEN.

1894—Early garden was a failure. Late garden did well, but was badly damaged by insects, especially grasshoppers.

1895—The planting of March 22 was a failure on account of dry weather. That planted May 15 produced a good stand, but was destroyed by grasshoppers and hail. That planted June 10 was destroyed by hail. Beans planted June 20 made a small crop.

1896—Planted May 2. Onions and beets proved a failure. Peas, beans, lettuce, sweet corn and popcorn did fairly well. No early garden planted. Summer squashes did well. All pumpkins were taken by bugs.

POPCORN.

1894–'95—None planted.

1896—Queen's Golden, White Pearl, White Rice and Red Jacket were tested, only a few hills of each variety being planted. Planted May 2. Each kind produced a few ears.

1897—The same varieties planted. Each produced a good yield.

1898—Queen's Golden and White Pearl planted May 18, producing a small yield.

1899—Queen's Golden planted May 17. But

few ears were produced; some plats dried up entirely.

RASPBERRIES.

1894—Twelve each of the Gregg and Cuthbert were set. Tops entirely winter killed.

1895—Tops all winter killed.

1896—Tops covered with stable manure—all winter killed.

1897—Canes covered with straw and manure—all winter killed.

1898—Bore a few berries on the new canes.

1899—Canes which were covered with dirt lived and bore a few berries. Twelve each of Progress, Egyptian and Queen were set. None lived.

DEWBERRY.

The first trial was made in 1899. Fifty each of Lucretia and Mammoth were set. Of the first variety twenty lived; of the second five lived.

GOOSEBERRIES.

1894—Six Downings were set: all lived.

1895—Twelve each of the Champion, Downing and Industry were set. No record of the location. Twelve lived.

1896—A few berries were produced.

1897—A small crop.

1897—A heavy crop.

1899—A small crop. In addition, ten each of the Houghton, Downing and Industry were set. Only three of the Houghton lived.

BLACKBERRIES.

1895—Three each of the Snyder and Wilson were set. None lived.

STRAWBERRIES.

1899—350 were set; 20 lived.

CURRANTS.

1894—Twelve of Fay's Prolifie were set; all lived through 1895.

1895—Of the Red Dutch variety twelve were set; six lived.

1896—Eleven lived.

1897—All dead.

1899—Five plants of each of the varieties named were set. Three of the first and four of the second lived.

DWARF JUNE BERRIES.

1899—Twelve were set, of which ten lived.

GRAPES.

1894—Of the Concord, six were set; none lived. Clinton, six set; four lived.

1895—Concord, six set; none lived. Clinton, three lived. Delaware, six set; four lived. Moore's Early and Worden, three of each were set; none lived.

1896—Two of the Clinton and three of the Delaware are alive.

1897—Two Clinton and three Delaware alive.

1898—One Clinton and three Delaware alive.

1899—Three Delaware alive—one blossomed.

FOREST TREES.

White ash—

1894—Fifteen set; all lived.
1895—Fifty set; one died.
1896—None set; two died.
1897—Planted May 13; a few grew.
1899—Planted May 25; none grew.

Russian mulberry—

1895—Twenty-five set; one died.
1897—3,000 set; 2,000 lived. Some planted May 13; none grew.
1899—Planted May 26; none grew.

Black locust—

1895—Fifty set; one died.
1897—Planted May 13: one-half grew. Some to height of five feet.
1899—Planted May 26; only a few grew.

Miscellaneous—

Hawthorn, Wild Black Cherry and European Ash, Planted May 13, 1897, and May 26, 1899; none grew.

Of the Boxelder, planted the same dates, a few grew in 1897; none in 1899.

In 1899, 1,000 Honey Locust	trees	were set;	438 lived.
100 Wild Black Chery	"	"	17 lived.
100 Catalpa	"	"	90 lived.
10 Russian Wild Olive	"	"	all lived.

Of the Boxwood planted in 1899, none grew. A few of the Coffee bean grew. Apricots were taken by squirrels, in 1899. A few Honey and Yellow locust grew in 1899.

The following tree seeds were planted May 26, but none grew:

Mahaleb Cherry,	Mazzard Cherry,
Sycamore Maple,	Norway Maple,
Sassafras,	Ailanthus,
Catalpa,	Buckthorn.
American Apple,	Black Walnut,
Catalpa (*speciosa*).	

CHERRY TREES.

Rocky Mountain Cherry—

1894–'95—Twelve set in each year. All lived.
1896—A small yield.
1897–'98—A heavy crop.
1899—A small crop.

Early Richmond—

1894—Six set.
1895—Twelve set; one died.
1897—A few cherries.
1898–'99—A small crop.

Common Morello—

1894—Six set; all lived.
1898-'99—A few cherries.

English Morello—

1895—Twelve set; seven lived and bore a few fine cherries in 1899.
1899—Two each of three varieties were set. Dye House, one lived; Large Montmorency, one lived; Ostheim, two lived.

Russian Apricot—

1895—Six set; none lived.
1899—Twelve set; all lived.

Dwarf pears—

1899—Two each of the Seckel, Anjou and Duchess were set; all lived.

Crab apple—

Five each of the Whitney and Martha were set in 1899. None of the first died.

German prunes—

Five set in 1899; none lived.

Peach trees, budded—

In 1899 five varieties were set: four Alexander, one lived; four Bailey's Seedling, two lived; three Champion, all lived; four Bokhara, four lived; four Elberta, two lived.

Plum trees—

1894—Six each of the Weaver and the Minor set, of which three died.
1895—Vacancies filled and three seedling Pond set; two died. Three Saratoga set; one died. Twelve Wild Goose; six died.
1896—No crop. No record of the location of previous year's planting to be found.
1897—Blossoms on the older trees. In addi-

tion three Wolf were set; two lived. Three American Eagle and three Cheney were set; all lived. Three Rollingstone were set; two lived. These grew well in 1898 and 1899.

1898—A few plums.

1899—A few plums on the 1899 trees. A few were on the 1895 planting, but none matured.

Apple trees—

1894—Four each of the Wealthy, Duchess of Oldenburg and Ben Davis were set; all lived. Damaged by hail in 1895. Made a small growth in 1896 and 1897. Made a moderate growth in 1898. Seemed thrifty in 1899

1895—Four varieties set. Twenty-five Ben Davis, of which 24 lived; 12 Utter's Red, 9 lived; 3 Missouri Pippin, 1 lived; 12 Geniton, 11 lived; 2 Romanite, 3 Belleflower, 5 Grime's Golden, 5 Red Astrachan; all lived. These made a small growth in 1896, and a moderate growth in 1897. In the latter year the trees in the northeast corner, where extra water runs in from the prairie, began to show a larger growth than those in the south west corner. Blossomed in 1898. The difference in the size of the trees in the northeast corner as compared with those in the southwest corner is still more marked. In 1899 one apple was matured. The trees in the northeast corner fully double the size of those of the same age in the southwest part of the orchard.

1897—Four each of the Sweet Bough, Plumb's Cider, Willow Twig and Mann were set. All lived. These were set very deep. In 1898 all made a good growth, but started slowly. In 1899 some of the trees set in

1896 were as large as the trees near them which were set in 1895.

MILLET.

1896—Four varieties, Common, German, Hungarian and Hog millet, were sown June 12. The first three were killed by dry weather. The last produced some seed and 16 pounds of hay.

1897—Four varieties were sown May 26. The figures after the names give the number of pounds of hay per acre obtained from them:

1.	Common	3090	2.	German	2290
3.	Hungarian	3190	4.	Hog Millet	2010
5.	Hirse	2240	6.	Common (Dakota grown seed)	2310
7.	California	3130			
8.	Golden Wonder	1790	9.	Manitoba	1810
10.	Early Harvest	2050	11.	Japanese	2210

1898—The first four varieties wer sown June 14 and 16, producing a small amount of hay—500, 300, 600 and 400 pounds, respectively, per acre.

1899—The same four varieties were planted May 31 and June 3, yielding 1,364, 0, 1,221 pounds, respectively, per acre. Seven other varieties were sown June 13, producing a small amount of hay and some seed. Golden Wonder produced 406 pounds of hay; ripened seed. Manitoba, 232 pounds of hay; Early Harvest, 406 pounds of hay; Japanese, 348 pounds hay; Russian (Salzer), 957 pounds hay; Russian (U. S. Department of Agriculture No. 2794), 406 pounds hay; Russian (U. S. Department of Agriculture No. 2960), no hay; ripened seed very early, but grew only one to three inches high.

LEGUMES.

Alfalfa—

1894—Sown May 14, taken by grasshoppers.
1895—Sown July 22, good stand.
1896—Partly killed.
1897—Small crop of hay.
1898—Small crop of hay.

1899—Plowed up to kill the grasshoppers. No crop. More was sown May 4, 1897; good stand. Yield one ton per acre in 1898. Some was sown May 20 1899—good stand.

Turkestan alfalfa—

Sown May 20, 1899; poor stand.

Clovers—

The seed of White clover, Medium Red, Mammoth, Crimson, and Alsike clovers was sown May 13, 1895. None germinated.

In 1897 seed of the same varieties, and also of Sand clover, Japan clover, *Medicago media*, *Medicago lupulina*, and *Vicia sativa*, was sown May 2. None grew.

Canada peas—

Sown April 8, 1895, taken by grasshoppers. Sown April 24, 1896, produced a small crop. Twelve varieties sown May 14, 1897, produced a small crop. Sown May 20, 1898, produced a small crop.

Sand vetch—

Sown May 26, 1896; a poor stand, but good growth. This produced seed in 1897 and was destroyed in 1898. Another sowing was made May 14, 1897, producing about half a stand, but made good growth. Destroyed in 1898. Same sown May 20, 1899—poor stand and small growth.

Lupines—

Three varieties were sown May 14, 1896. All were taken by grasshoppers.

Cowpeas—

Blackeyed (home-grown seed), was planted June 14, 1896; yield, two bushels. 1897, planted May 14; yield, 9.9 bushels. 1898,

planted April 20; yield, six bushels. Same variety, from Plant of St. Louis, planted April 20, 1898; yield, a few ripe pods. The Whip-poor-will cowpeas, planted same date, gave a few ripe pods; and the Black cowpeas gave one and one-half bushels.

Idaho peas—

First planting May 14, 1897. Mostly taken by grasshoppers. Planted April 20, 1898, produced eleven bushels. Planted May 23, 1899, taken by beetles.

Beans—

Navy beans, planted May 14, 1897; failure. Planted April 20, 1898; small yield. Planted May 23, 1899, taken by insects.

Tree beans—

Planted same dates as above (1897), yield large crop; taken by beetles in 1898; produced four bushels in 1899.

SORGHUMS.

1894—Five varieties were sown May 8 and 9. White Kaffir corn produced 400 pounds of fodder per acre; Jerusalem corn, 455 pounds; White Milo maize, 390 pounds; large African millet, 375 pounds. Red Kaffir corn, no report.

1895—White Kaffir corn, sown June 14, gave 3,000 pounds; Jerusalem corn, White Milo maize, Russian maize, and Egyptian Rice corn, sown May 22, taken by grasshoppers. Early Amber cane, sown May 25, gave a large yield, but no estimate is found.

1896—White African, sown June 3, gave 2,000 pounds; White Milo maize and Red Kaffir corn, sown same date, gave 2,200 pounds. Egyptian Rice corn, sown same date, gave 1,800 pounds of fodder. The rest were sown May 26. Jerusalem corn, which was damaged by hail, gave 600 pounds of seed. Large African millet, no seed, fodder de-

stroyed by hail. Early Amber cane produced a little seed, and 2,500 pounds of fodder. Fodder cane, no seed. Brown Durra, 1,250 pounds of seed. Yellow Milo maize and Black Rice corn gave a little seed. Kaffir corn No. 39, some seed, but little fodder. The hailstorm of August 21 cut most of the fodder off from the last five varieties, leaving only the stalks.

1897—Seed was sown May 19, except one variety. The White and Red Kaffir corn, Large African millet, Early Orange cane, gave no seed. Yellow Milo maize, Black Rice corn, Kaffir corn No. 39 and Early Minnesota cane gave some seed. Jerusalem corn gave 750, and Brown Durra, 850 pounds of seed. The Early Amber cane, sown June 5, gave 5,600 pounds where sown on sod, 4,560 pounds on old ground, and 6,000 pounds where drilled and cultivated.

1898—Ten varieties were sown May 27. White Kaffir corn gave 6,720 pounds of fodder per acre. Red Kaffir corn, 5,320 pounds; Large African millet, 6,565 pounds of fodder; Jerusalem corn 750 pounds of seed; Early Amber cane. 6,192 pounds of fodder; Brown Durra, 1,000 pounds of seed; Yellow Milo maize, 5,110 pounds of fodder; Black Rice corn, 4,970 pounds of fodder; Early Orange cane, 8,400 pounds fodder; Kaffir corn No. 39, 600 pounds seed.

1899—Sixteen varieties were sown from May 18 to May 22, yielding as follow: Red Kaffir corn, 486 pounds fodder; Early Amber cane, 1,032 pounds, some seed; Fodder cane, 924 pounds, no seed; Brown Durra, 300 pounds seed; Kaffir corn No. 39, some seed; Early Minnesota cane, some seed, 1,500 pounds fodder; Early Orange cane, no seed, 1,512 pounds fodder; Folger's Early cane, 1,308 pounds fodder; White African cane. 780 pounds fodder; Collier cane, no seed, 756 pounds fodder; Coleman cane, no seed, 744 pounds fodder.

Five varieties from the U. S. Department of Agriculture: Edgar cane (No. 2373), a little seed,

500 pounds of fodder. Variety No. 161 (No. 2,363), some seed, 1,000 pounds of fodder. Honey Dew (No. 2,367), some seed, 1,500 pounds of fodder. Folger's Early (No. 2,291), no seed, 400 fodder. Chinese (No. 2,372), no seed, 200 pounds of fodder.

MISCELLANEOUS WORK.

1894-1895—No record of any work except the culture of crops.

1896—Tested capillary rise of water in four types of soil.

Examined soil of cultivated land by boring holes and making notes concerning character of soil found. Bored holes and noted strata in 280 places on the northeastern 40 acres of the farm.

Twelve rods of sod wall wind break was built.

1897—Built solid board fence, continuing wall made of sod in 1896 until the two are twenty-two rods long.

The work connected with variety tests of crops was so great that no scientific work was done.

1898—Filled buckets with soil and placed them at different distances from the wall. These were weighed at intervals. Results were reported in the annual report for 1898.

Eight galvanized-iron cans 52 inches deep and 18 inches in diameter, were filled with soil for the purpose of testing the amount of water used by crops. Also, testing evaporation from different soils. It was found that too much work was already on hand to do this work properly. Two tanks 18 inches in diameter and 52 inches deep, were filled with water. One shaded, the other left in the sun. Evaporation from the two has been reported.

1899—About 16 acres of cultivated land was surveyed to determine the levels. Also the levels of the ravine were determined for the purpose of estimating probable cost and utility of dams.

APPENDIX TO REPORT OF METEOROLOGIST.

R. E. Trimble, Observer,

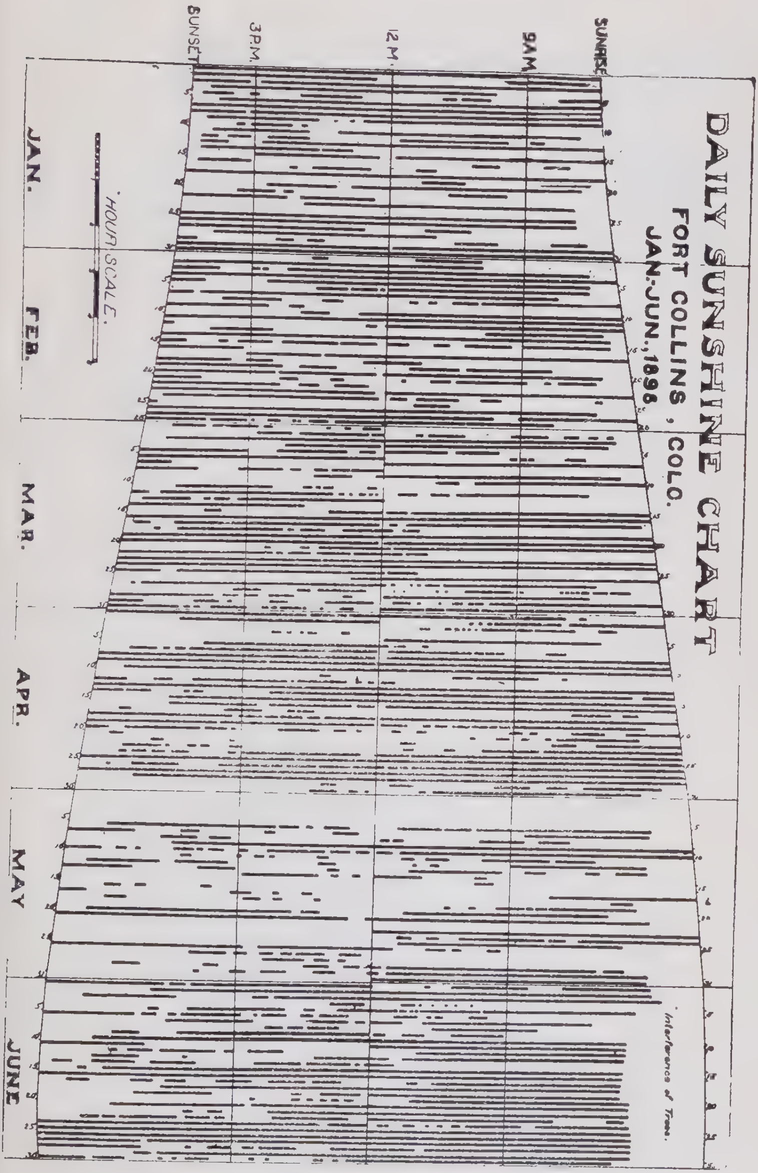
METEOROLOICAL OBSERVATIONS.

The meteorological observations include ordinary weather observations, and a series bearing directly on agricultural meteorology. These include eye readings, twice daily, of standard instruments, and records from a number of self-recording instruments, principally of the Richard pattern. These include a self-recording raingage, barograph, thermograph, psychrograph, statoscope, evaprometer, anemograph, sunshine, recorder, etc.

The year 1899 was one with temperature below the normal. The winter of 1898-'99 was one of unusually low temperatures. The month of February averaged 15° below the normal. For sixteen consecutive days the thermometer fell below zero. During the existence of our record the tempetature has been below —20° but seven times, never below —30°. But in February, for four consecutive days—February 4-7—the temperature dropped below —30°, and again on the 11th and 12th. On two days—February 6 and 12—it reached —38°. On February 2 and 11, the highest temperature of the day remained below zero. The extreme cold was trying on plant life especially, and the losses were unusual in amount.

The year also furnished the greatest change in temperature observed in one day. Up to this year, the greatest range observed had been 56°, in February, 1895. On the morning of February 12, the minimum temperature was —38.4°. During the afternoon it rose to +16°, and fell again to —1° by midnight; but rose to +37° by 6 A. M., on the 13th, or a change of 75° in twenty-four hours.

The precipitation was not so unusual in amount, but a larger proportion than usual fell early in the winter, and the extreme cold permitted it to remain on the ground unmelted or unevaporated. The supply of water for irrigation was, therefore, unusual in amount with the streams of northern Colorado. On the headwaters of the Rio Grande it was deficient.


DAILY SUNSHINE CHART
FORT COLLINS, COLO.
JAN.-JUN., 1898.
SUNRISE
9 A.M.
12 M.
3 P.M.
SUNSET
HOUR SCALE.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
Interference of Trees.

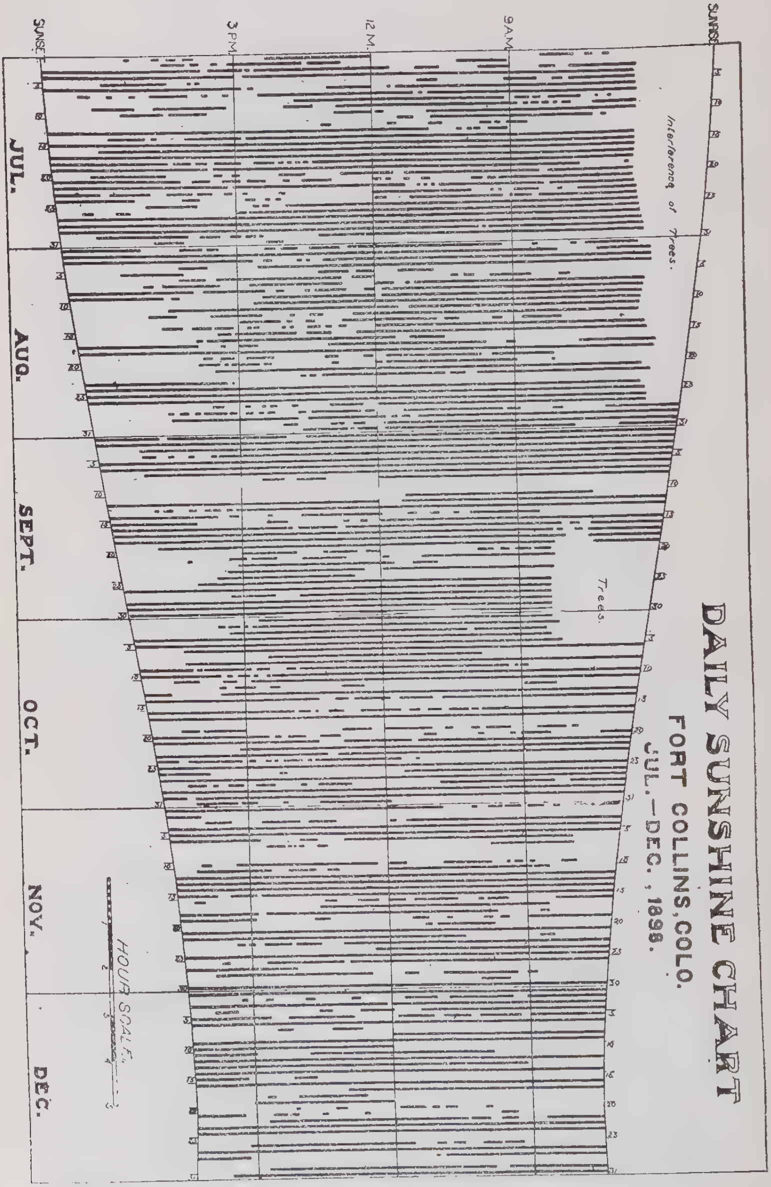

DAILY SUNSHINE CHART
FORT COLLINS, COLO.
JUL.—DEC., 1898.
SUNSET
3 P.M.
12 M.
9 A.M.
SUNRISE
JUL.
AUG.
SEPT.
OCT.
NOV.
DEC.
Interference of Trees.
Trees.
HOUR SCALE.

TABLE 1.

SUMMARY FOR 1898 and 1899, AT AGRICULTURAL COLLEGE, FORT COLLINS, COLO.

Latitude, 40° 34; Longitude, 105° W from Greenwich; Elevation of Barometer, 4,994 ft; ground, 4,980 ft

FOR 1898.

1898 Month	Mean ½ max+min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Average Temp'ture below 32°	Minimum below 32°	Precipitation. (Rain or Melted Snow.)	Snowfall	No. of Stormy Days	Relative Humidity	Dew Point	Frost No. dys. Frost	Dew or Dew Obsv'd
												No. of Days	No. of Dys	Ins.	Ins.		Per Ct.	F°		
Jan....	25.6	40.7	10.6	13.8	23.5	61.5	-11.8	30.1	47.4	12.4	20.2	24	31	0.14	1.38	3	75.2	11.0	15	..
Feb	34.1	50.6	17.6	21.8	32.0	63.7	6.7	33.0	43.0	19.6	26.7	12	28	0.08	.83	2	67.5	16.2	17	..
March..	32.7	47.9	17.5	24.5	32.8	66.3	-6.2	30.4	48.9	21.9	26.4	13	30	0.50	5.25	8	62.6	15.2	12	..
April..	47.7	64.5	30.9	43.3	50.7	86.2	14.5	33.6	55.2	36.8	39.7	1	16	1.08	1	9	52.4	27.3	7	..
May	51.6	62.7	40.4	48.8	53.0	81.8	29.6	22.3	43.5	44.7	45.9	0	7	3.65	13	22	71.4	40.4	1	7
June ..	64.0	79.9	48.2	60.4	66.7	97.2	36.0	31.7	50.5	53.9	55.9	0	0	1.37	0	7	62.7	49.1	0	19
July....	69.0	85.1	53.0	64.2	71.8	97.0	44.3	32.1	46.8	57.2	59.7	0	0	0.50	0	8	60.9	52.2	0	15
August	69.9	87.6	52.2	62.5	71.2	95.6	43.1	35.5	49.2	56.0	57.9	0	0	0.98	0	7	59.0	50.6	0	16
Sept...	58.6	78.3	38.8	47.5	57.1	90.2	29.7	39.4	55.5	42.2	46.8	0	2	0.50	0	4	60.1	37.0	2	7
Oct....	46.3	61.0	31.5	37.7	44.5	85.7	16.2	29.6	50.5	31.9	36.1	0	16	0.82	1	4	55.6	24.0	15	..
Nov ...	30.3	44.5	16.1	23.6	27.8	71.3	-11.3	28.4	49.5	20.5	24.2	17	28	1.24	11 5	4	72.4	16.5	11	.
Dec ...	23.6	37.9	9.3	13.2	19.6	55.0	-22.3	28.7	46.8	11.4	16.6	24	31	0.17	3.5	2	73.6	8.4	17	..
Year...	46.1	61.7	30.5	38.4	45.9	97.2	-22.3	31.2	55.5	34.0	38.0	91	189	11.03	37.46	80	64.5	29.0	97	64
Norm'l	46.5	61.9	31.8	39.5	46.8	99.2	-28.4	30.2	56.2	35.1	39.0	......	....	13.68	......	70.6	64.5	30.2	..	.

FOR 1899.

Month	Mean ½ max+min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Average Temp'ture below 32°	Minimum below 32°	Precipitation	Snowfall	No. of Stormy Days	Relative Humidity	Dew Point	Frost	Dew
Jan....	24.7	39.0	10.4	16.6	24.3	55.0	-16.8	28.6	57.8	14.1	20.8	24	31	0.66	11¼	6	70.2	10.6	8	..
Feb....	9.9	25.3	-5.5	1.6	10.6	50.8	-38.4	30.7	75.4	0.8	9.1	26	28	1.04	14.0	11	87.2	2.4	14	.
March.	29.7	41.6	17.9	24.2	29.9	65.7	-24.5	23.7	51.4	21.9	26.4	17	29	1.50	19.8	11	73.7	18.8	13	..
April..	44.7	60.5	28.9	40.3	47.8	78.0	8.0	31.6	51.0	34.2	37.4	4	20	1.10	4.75	6	53.2	24.6	11	..
May....	53.8	69.5	38.0	49.7	56.8	82.5	23.4	31.6	45.6	43.4	45.1	0	4	1.01	0	8	53.2	34.6	5	3
June...	63.6	79.8	47.4	60.0	66.8	96.1	36.4	32.5	50.9	51.8	53.7	0	0	1.03	0	9	54.5	44.6	1	14
July...	67.0	81.3	52.7	63.0	67.2	94.0	44.6	28.6	49.0	57.5	59.6	0	0	4.95	0	13	70.8	54.8	..	19
August	67.6	84.2	51.9	62.3	67.0	95.2	39.7	33.1	50.7	55.4	57.0	0	0	0.99	0	7	63.1	50.3	..	16
Sept...	61.4	80.3	42.4	52.8	59.3	94.6	29.0	37.9	52.6	46.5	49.8	0	3	0.21	0	3	60.8	41.6	4	12
Oct....	46.1	60.2	31.9	37.3	43.4	86.7	23.7	28.3	54.0	37.3	38.0	0	13	3.23	1¾	10	72.7	30.7	8	..
Nov....	40.8	56.6	24.9	29.1	37.4	69.5	15.0	31.8	48.1	26.5	31.9	1	27	T	T	0	69.2	23.1	6	..
Dec...	27.7	42.6	12.7	19.8	24.3	63.7	-9.3	29.9	51.2	17.3	20.9	23	31	0.47	6.0	3	74.1	13.1	16	..
Year...	44.7	60.1	29.5	38.1	44.6	96.1	-38.4	30.7	75.4	33.9	37.5	95	186	16.19	57.5	87	66.9	29.1	86	64
Norm'l	46.4	62.1	31.7	39.4	46.0	* 99.2	* -38.4	30.2	* 75.4	34.9	38.8	......	....	13.84	......	71.6	64.7	30.1	..	..

* Extreme values.

TABLE 2.

SUMMARY FOR 1898 and 1899, AT ARKANSAS VALLEY SUBSTATION, ROCKY FORD.

W. F. CROWLEY. OBSERVER, JANUARY TO MARCH; H. H. GRIFFIN, FROM MARCH 1.

Latitude 39° 3′; Longitude 103° 45′; Elevation 4,160 feet.

FOR 1898.

Month.	TEMPERATURE (IN DEGREES FAHRENHEIT)													Precipitation. (Rain or Melted Snow.)	Total Snowfall	No. of Stormy Days	Relative Humidity Mean	Dew Point, Mean	No. dys. Frost or Dew Obsv'd		Prevailing Direction of Wind
	Mean	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32	Minimum Below 32						Frost	Dew	
Jan....	27.6	42.6	12.7	17.2	27.7	61	–10	29.8	47	15.8	24.7	20	31	.40	3.4	1	77.9	16.1	20	—	n w
Feb....	38.5	55.9	21.1	29.0	39.8	74	12	34.8	52	24.7	33.0	4	27	0.	0.	0	65.0	21.1	28	—	n
March..	40.1	57.5	22.7	30.6	44.2	74	2	34.8	58	26.5	34.8	4	27	.16	1.	2	51.9	18.1	25	—	n
April..	53.5	69.4	37.6	46.0	55.5	86	23	31.8	48	41.1	45.6	0	6	1.06	1.	6	58.5	35.2	8	—	e
May ...	57.6	70.7	43.5	53.7	60.0	90	30	26.1	42	49.2	51.7	0	1	2.71	4.	10	68.7	45.5	..	—	e n e
June ..	69.5	83.7	55.3	64.0	71.1	99	41	28.4	40	57.1	60.1	0	0	3.16	—	3	62.6	53.3	—	6	e
July ...	74.2	88.9	59.4	67.4	74.4	99	53	29.6	44	61.3	63.2	0	0	3.52	—	6	65.2	57.6	—	11	e
Aug ...	74.4	91.3	57.4	64.6	74.2	100	52	33.9	43	59.0	63.3	0	0	.92	—	3	65.8	56.6	—	20	n e
Sept ...	61.1	79.3	42.9	51.7	62.9	96	32	36.4	50	46.8	53.1	0	0	1.55	—	4	64.9	44.2	1	6	n
Oct....	49.3	65.7	32.9	40.8	51.1	90	20	32.8	48	36.0	42.3	0	16	1.36	......	4	60.2	31.6	..	..	n n e
Nov....	37.4	54.0	20.8	26.4	36.3	80	2	33.1	58	23.2	30.2	10	26	.37	.25	4	53.1	18.8	..	..	n
Dec....	24.1	38.8	9.4	15.7	22.7	64	-17	29.4	50	14.6	20.4	21	31	.96	8.	4	71.7	12.4	..	..	n n w
Av.....	50.6	66.5	34.6	42.3	51.7	*100	*–17	31.7	58	37.9	43.5	59	16.5	16.17	17.65	47	64.6	34.3	..	..	......
....	....	....	....	....	....	....	....	....	....	....	....	....	....	......	......	...	....	....	..	..	......

FOR 1899.

Month.	Mean	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32	Minimum Below 32	Precipitation. (Rain or Melted Snow.)	Total Snowfall	No. of Stormy Days	Relative Humidity Mean	Dew Point, Mean	Frost	Dew	Prevailing Direction of Wind
Jan....	27.4	42.6	12.1	16.9	26.5	61	–20	30.5	48	15.1	23.1	18	30	0.98	8.	3	73.7	13.8	--	—	n w
Feb. ...	16.9	33.1	0.6	-4.1	9.3	60	–32	32.5	52	-4 5	7.7	22	28	0.55	6.5	4	83.3	-1.8	..	..	n
March .	40.2	57.6	22.7	28.9	41.7	82	2	34.9	52	25.4	34.1	6	28	0.32	4.	3	60.0	20.7	..	..	n n e
April ..	52.7	71.3	34.1	43.9	55.7	87	18	37.2	56	37.1	41.9	0	13	0.28	0.5	2	44.7	26.4	..	..	n e
May. ...	62.0	79.0	45.0	55.3	65.8	94	32	34.0	46	46.7	50.1	0	0	0.99	......	4	46.7	35.8	2	4	w n w
June...	70.9	88.2	53.6	63.8	73.1	105	43	34 6	49	56.1	57.6	0	0	0.78	......	6	53.1	48.2	..	..	e
July ...	72.5	87.0	58.0	66.3	72.5	102	53	29.0	45	61.6	63.1	0	0	7.00	......	9	71.1	58.5	..	9	n w
August	73.7	90.8	56.6	65.5	75.9	99	45	34.2	51	58.7	63.8	0	0	2.22	......	5	61.4	55.8	..	9	n n e
Sept ...	65.8	83.8	47.8	55.4	66.5	99	35	36.0	54	50.4	56.3	0	0	1.43	......	5	65.1	47.9	..	10	n e
Oct	53.9	71.8	36.0	44.4	54.9	92	22	35.9	54	38.6	44.3	0	10	0.63	......	2	54.6	32.2	2	..	n e
Nov....	43.9	59.3	28.5	32.5	43.2	74	19	30.8	49	30.6	38.4	0	24	2.40	......	4	75.8	30.1	..	..	n n w
Dec....	27.1	41.7	12.6	18.3	25.2	66	-20	29.1	49	17.0	22.8	22	31	0.98	13.	3	81.0	16.3	..	..	n w
Av.. .	50.6	67.2	34.0	40.6	50.9	*105	*-32	33.2	56	36.0	41.9	68	164	18.56	20.0	50	64.2	32.0	..	..	n
Norm'l	51.4	68.3	35.0	42.7	52.6	....	....	33.1	....	38.9	45.3	....	....	13.76	......	38.8	67.3	36.8	..	..	......

* Extreme values.

TABLE 3.

SUMMARY FOR PLAINS SUBSTATION, CHEYENNE WELLS, J. E. PAYNE, OBSERVER.

Latitude 38° 50'; Longitude 102° 20'; Elevation 4273 Feet.

FOR 1898.

TEMPERATURE (DEGREES FAHRENHEIT) Mean ½ max min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	NO. DAYS Av. Temp. Below 32	NO. DAYS Minimum Below 32	Precipitation. (Rain or Melted Snow)	Total Snowfall	No. Stormy Days	Relative Humidity Mean.	Dew Point. Mean	No. Dys. Frost or Dew Obsv'd Frost	Dew	Average Cloudiness	Prevailing Direction
28.9	43.3	11.7	21.8	27.6	69.2	0.0	28.8	50.5	19.0	21.4	20	31	.03	.25	1	64.1	12.0	14	–	3.2	n n
35.0	52.2	17.8	26.7	31.3	70.4	4.2	34.4	53.8	22.5	24.6	9	28	.00	0	0	52.5	10.8	7	—	2.6	w n
35.7	52.9	18.5	28.7	34.7	72.0	-12.0	34.4	53.2	21.4	28.3	8	30	.61	2.00	2	59.4	15.3	4	—	4.7	w n
49.1	64.3	34.0	46.1	50.0	83.6	18.6	30.3	45.2	39.8	40.4	1	12	1.10	1.	5	55.7	30.8	2	—	4.0	s e
55.3	67.3	43.4	51.8	54.3	89.0	31.0	23.9	42.8	47.4	48.9	0	3	5.56	3.	12	75.0	44.1	1	1	5.5	n e
67.8	80.9	54.6	64.6	69.7	97.0	39.4	26.3	39.2	58.0	60.6	0	0	3.95		6	67.0	51.8	—	8	4.1	s s
72.8	86.7	59.0	70.7	73.2	97.2	51.8	27.7	43.2	61.2	58.1	0	0	2.79	—	5	58.1	51.5	—	5	4.0	s e
73.7	89.2	58.2	69.[illegible]	[illegible]	97.5	52.0	31.1	40.[illegible]	69.[illegible]	50.4	0	0	1.33	–	5	57.6	53.8	–	7	2.7	s
62.2	78.4	45.9	55.[illegible]	61.2	95.2	31.6	32.5	46.0	47.8	50.3	0	2	2.00	5.10	5	60.0	40.9	3	8	2.6	w s
47.0	62.6	31.4	40.9	44.4	84.0	19.0	31.2	45.8	35.7	37.5	0	21	0.48	1.85	3	61.6	28.8	9	—	2.6	n w
33.4	49.2	17.6	25.4	24.5	75.6	-12.0	31.6	47.4	22.4	25.1	14	28	0.50	2.16	3	69.6	17.1	14	—	3.3	w n
25.1	40.4	11.8	18.[illegible]	20.3	67.6	-17.4	28.6	47.6	16.3	17.7	22	31	.48	2.70	3	74.9	11.7	20	—	3.8	n w
48.9	64.0	33.9	43.3	47.3	97.5	-17.4	30.1	53.8	37.9	39.4	74	186	18.13	18.06	50	63.0	31.0	74	29	3.6	w n
....	....	....	....	....	......	......	....	....	....	....	....	....	......	......	....	....	....	..	..	....	....

FOR 1899.

Mean ½ max min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32	Minimum Below 32	Precipitation	Total Snowfall	No. Stormy Days	Relative Humidity Mean	Dew Point Mean	Frost	Dew	Average Cloudiness	Prevailing Direction
26.4	42.0	10.7	18.2	23.8	60.6	-16.8	31.3	45.6	16.6	20.9	20	31	0.47	4.2	4	76.9	14.1	13	..	4.2	w s
14.9	28.5	1.3	9.1	13.1	58.6	26.4	27.2	53.6	8.2	11.7	23	28	0.36	2.95	4	84.7	7.0	8	..	4.6	w n
34.9	50.1	19.9	27.2	32.4	76.4	5.6	30.0	51.0	24.7	28.1	12	29	0.39	3.0	3	71.8	20.4	8	..	4.9	n w
49.8	67.4	32.2	45.7	50.9	83.4	15.2	35.2	50.8	37.7	39.1	0	16	0.03	T	1	46.4	24.4	7	1	4.1	s e
59.5	75.8	43.3	56.6	60.6	90.8	26.4	32.5	53.6	48.0	48.2	0	3	2.88	.....	5	51.2	37.1	1	3	3.2	s e
68.8	85.0	52.6	65.5	69.1	102.4	39.0	32.4	49.4	56.2	55.4	0	0	1.89	......	6	54.0	46.8	..	5	4.1	s e
71.9	85.1	58.6	68.3	71.4	98.6	51.8	26.6	39.6	62.6	62.7	0	0	3.67	......	11	70.5	58.9	..	9	4.8	s e
75.6	91.5	59.8	71.4	76.8	101.0	50.5	31.8	45.6	59.6	59.9	0	0	0.55	.. .	3	47.8	50.4	..	2	2.3	s e
66.3	83.0	49.6	61.5	65.7	101.6	32.0	33.3	47.8	52.7	53.9	0	0	0.78	......	3	56.0	45.3	1	2	2.7	s
53.4	69.1	37.2	46.7	52.2	93.2	25.6	32.4	45.2	41.2	44.8	0	7	T	......	0	63.3	35.9	2	..	3.2	n w
43.4	57.9	28.9	34.6	43.7	71.0	4.0	29.0	54.0	31.8	38.8	1	20	2.49	.....	3	72.9	30.4	3	..	3.6	n w
28.1	38.3	17.9	23.1	26.5	62.6	0.8	20.4	41.0	21.7	25.3	21	29	0.55	4.0	3	86.5	21.1	6	..	4.3	w n
49.4	64.5	31.3	44.0	48.8	102.4	26.4	30.2	54.0	38.4	40.7	77	163	14.06	......	46	65.2	32.6	49	22	3.8	s w
50.0	65.0	35.1	44.5	49.0	......	......	29.8	....	39.4	41.7	...	....	15.55	......	43.9	67.4	34.4	..	..	.....	.....

TABLE 4.

SUMMARY AT MR. CARLYLE LAMB'S AT THE BASE OF LONG'S PEAK, ESTES PARK P. O., COLO. ELEVATION 9,000 FEET, APPROX.

FOR 1898.

MONTH	Mean Temperature	Average Maximum	Average Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. of Days: Average Below 32°	No. of Days: Minimum Below 32°	Precipitation Inches	Snowfall Inches	No. Stormy Days
January	20.0	32.3	7.7	56	-21	24.6	47	27	29	0.40	5.	4
February	23.8	38.4	15.3	52	0	23.0	39	20	28	0.45	9.	3
March	23.6	35.1	12.0	52	-14	23.1	41	25	31	0.59	13.25	5
April	36.3	49.3	23.3	67	0	26.0	52	5	25	1.73	17.	5
May	38.4	49.7	27.2	64	8	22 5	36	7	21	1.82	17.75	10
June	50.5	64.2	36.7	79	23	27.5	46	0	6	2.06	4.	5
July	53.4	65.4	41.3	73	34	24.1	36	0	0	2.94	—	7
August	56.6	71.8	41.5	81	33	30.3	43	0	0	1.53	0.	8
September	50.4	66.0	35.2	78	21	30.5	46	1	10	0.81	1.	2
October	38.5	50.3	26.6	65	13	23.0	43	6	20	0.60	7.5	3
November	27.2	36.8	16.9	57	-12	20.0	54	15	21	1.60	23.	4
December	20.0	31.7	8.4	51	-24	23.4	51	28	31	0.60	9.	3
Year	36.8	49.2	24.3	81	-24	24.8	54	134	222	15.13	106.5	59

16th to 31st July Temperature missing.

FOR 1899.

MONTH	Mean Temperature	Average Maximum	Average Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. of Days: Average Below 32°	No. of Days: Minimum Below 32°	Precipitation Inches	Snowfall Inches	No. Stormy Days
January	21.7	30.9	12.6	46	- 7	18.3	44	28	31	0.52	7¼	5
February	15.4	23.9	7.0	43	-31	17.0	44	26	28	1.05	16¼	10
March	23.8	33.6	14.0	54	-22	19.6	43	24	28	2.97	39¾	11
April	35.4	46.6	24.3	60	- 1	22.3	36	8	24	1.10	13½	6
May	41.9	54.6	29.2	65	17	25.5	36	2	21	0.38	5	4
June	50.2	64.3	36.0	79	22	28.3	44	0	9	1.09	¼	6
July	54.6	68.7	40.6	78	37	28.1	40	0	0	3.32		16
August	56.0	69.9	42.0	79	32	27.9	38	0	0	1.73		8
September	51.5	67.6	35.4	82	20	32.2	40	0	7	0.11		1
October	37.3	49.1	25.5	69	8	23.6	42	6	26	2.31	29	8
November	35.1	47.2	23.0	59	6	24.2	44	10	25	.03	½	1
December	25.5	37 2	13.8	55	- 9	23.3	52	23	28	0.62	11½	4
Year	37.4	49.5	25.3	82	-31	24.2	52	127	227	15.23	123	80
Normal	37.5	49.6	25.4	85	-31	24.2	54	126	220	17.86		68

TABLE 5.

SUMMARY AT MR. GEO. A. BARNES', PINKHAMPTON, NORTH PARK, COLO. ELEVATION 8,400 FEET.

FOR 1898.

MONTH	Mean Temp. ½ (7a+7p)	Av. Temp. 7 a. m.	Av. Temp 12 m.	Av. Temp. 7 p. m.	Highest	Lowest	Mean Range	Greatest Range	No. Dys. Averaging Below 32	No. Days Minimum Below 32°	Precipitation	Snowfall	No. Stormy Days
January	10.3	3.9	29.8	16·7	48	-25	26.0	47	31	31	.45	4.5	5
February	21.8	16.2	38.8	27.4	54	- 4	12.3	46	26	28	.52	5.25	4
March..........	20.6	15.3	37.1	26.0	55	-10	22.9	45	31	31	1.30	13.	9
		Min.		Max.									
April	42.5	28.8	....	56.2	75	8	27.4	50	2	19	·.33	......	5
May............	47.5	36.3	....	58.6	78	16	22.3	42	0	8	2.10	—	12
June...........	60.4	44.0	....	76.8	90	32	32.8	44	0	0	0.66	5.	6
July	65.8	49.9	....	81.6	94	40	31.8	48	0	0	0.50	—	6
August	64.0	46.4	....	81.5	90	37	35.2	52	0	0	0.82	—	10
September.....	53.4	33.3	....	73.6	92	20	40.4	62	0	11	0.15	0.5	2
October	38.2	26.8	....	49.6	72	8	22.8	50	5	21	1.51	13.	6
November......	26.4	15.6	....	37.2	70	-12	23.1	48	20	24	2.10	21.	6
December	13.2	1.7	....	24.7	54	-27	23.0	38	29	31	1.50	15.	3
Year..........	38.7	......	....	......	94	-27	26.7	62	144	204	11.94	77.25	74

FOR 1899.

MONTH	Mean Temperature	Average Maximum	Average Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. Days Av. Below 32°	No. Days Min. Below 32°	Precipitotion	Snowfall	No. Stormy Days
January	21.8	30.0	13.6	46	- 12	16.4	36	28	31	3.33	50	12
February.........	19.1	29.7	8.6	53	-42	21.1	50	23	28	3.60	54	14
March	30.8	41.6	20.2	62	-15	21.4	54	17	26	2.60	39	10
April.............	40.1	56.1	24.2	76	4	31.9	56	5	26	1.60	24	10
May	46.7	58.0	35.4	72	16	22.6	36	2	7	0.27	2	3
June..............	56.6	71.1	42.0	90	30	29.1	46	0	1	0.60	... ..	8
July..............	64.3	79.7	48.8	91	40	30.8	48	0	0	1.18	......	13
August	60.4	77·2	43.5	86	28	33.7	48	0	1	0.91	......	8
September	54.6	74.2	34.9	88	26	39.3	52	0	9	0.30	......	3
October	41.3	53.2	29.4	76	16	23.8	56	1	18	3.09	......	5
November........	36.4	48.5	24.3	64	7	24.2	44	6	20	T	......	0
Decembsr	19.1	28.7	9.4	44	-28	.19.4	40	29	30	1.17	17½	5
Average	40.9	54.0	27.9	91	-42	26.1	56	111	197	18.65	186½	91

Precipitation in winter months deduced from snowfall.

TABLE 6.

SUMMARY AT GLENEYRE P. O., MRS. F. W. SHERWOOD, OBSERVER. NEAR HEAD OF THE LARAMIE RIVER, ELEVATION 8,000 FEET.

FOR 1898.

MONTH	Av. Temp. 7 a. m.	Av. Temp. 2 p. m.	Av. Temp. 9 p. m.	Mean Temp. ½ (Max+Min)	Av. Maximum	Av. Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. Days Av. Below 32°	Days Minimum Below 32°	Precipitation Inches	Snowfall	No. Stormy Days
January	10.9	25.9	16.4	15.5	26.7	4.3	44	-22	22.5	47	29	31	....	4	2
February	21.2	33.6	23.1	25.4	35.6	15.1	49	- 2	20.5	35	20	28	....	1	1
March	17.3	32.2	20.6	23.0	34.7	11.3	50	-13	23.4	42	27	31	....	20	8
April	30.6	49.1	34.0	39.2	53.8	24.6	73	3	29.2	48	4	26	....	16	7
May	38.0	54.7	38.2	44.4	57.9	31.0	80	10	26.9	43	2	14	....	10	6
June	50.9	71.8	50.0	56.9	74.3	39.5	90	28	34.8	52	0	7	.70	T	7
July	55.9	76.0	53.1	61.5	80.3	42.7	90	34	37.6	52	0	0	.70	—	5
August	52.4	75.9	52.5	60.4	78.2	42.5	88	34	35.7	49	0	0	....	—	....
September	44.9	67.0	39.6	50.6	70.3	30.8	81	18	39.5	54	0	15	....	5	3
October	31.8	48.3	28.8	36.8	50.5	23.2	69	5	27.3	43	8	26	....	19	7
November	18.1	35.8	19.4	23.9	37.3	10.5	59	-11	26.8	42	22	28	....	12	4
December	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Year	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

FOR 1899.

MONTH	Av. Temp. 7 a. m.	Av. Temp. 2 p. m.	Av. Temp. 9 p. m.	Mean Temp. ½ (Max+Min)	Av. Maximum	Av. Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. Days Av. Below 32°	Days Minimum Below 32°	Precipitation Inches	Snowfall	No. Stormy Days
January	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
February	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
March	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
April	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
June	48.6	65.9	46.6	54.9	73.7	36.1	97	22	37.6	60	0	6	1.00	....	15
July	54.0	71.7	50.8	59.5	77.1	42.0	94	35	35.2	49	0	0	1.00	....	15
August	51.5	72.4	50.5	59.1	78.4	39.7	87	28	38.7	55	0	4	.50	....	5
September	42.8	70.5	44.9	53.3	84.6	31.9	90	20	42.7	57	0	16	T	....	0
October	31.4	47.0	31.0	36.9	49.7	24.1	71	4	25.6	53	11	26	2.53	38	8
November	26.6	45.7	29.3	33.8	47.6	20.1	63	7	27.5	48	10	29	0.40	4	2
December	12.9	25.5	15.1	16.6	26.9	6.3	44	-19	20.6	36	30	31	2.90	29	10
Average	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

The precipitation and stormy days are partly estimated.

TABLE 7.

WEEKLY MEANS OF SOIL TEMPERATURES SET A. IN AN IRRIGATED PLAT NEAR THE COLLEGE BUILDING. IN DEGREES FAHRENHEIT.

FOR 1898.

Week Ending	DEPTH						Week Ending	DEPTH					
	3 in.	6 in.	1 ft.	2 ft.	3 ft.	6 ft.		3 in.	6 in.	1 ft.	2 ft.	3 ft.	6 ft.
Jan. 8.	29.69	30.04	31.40	34·96	38.93	48.23	July 9.	73.69	73.06	72.42	68.80	6 6.21	58.67
" 15.	28.22	29.08	30.94	34.66	38.50	47.44	" 16.	75.83	75.39	74.19	70.26	67.44	59.80
" 22.	27.21	28.12	29.91	33.88	37.82	46.70	" 23.	76.97	76.89	76.11	72.23	69.16	61.01
" 29.	26.44	27.28	29.13	33.29	37.19	45.91	" 30.	76.84	76.78	76.14	72.69	70.03	62.11
Feb. 5.	28.47	29.02	30.11	33.05	36.65	45.41	Aug. 6.	72.51	72.97	73.25	71.66	69.96	62.95
" 12	30.87	31.11	31.30	33.05	36.51	44.64	" 13	70.52	70.89	70.76	69.74	68.82	63.33
" 19.	31.56	31.49	31·66	33.36	36.50	44.14	" 20.	74.23	74.15	73.32	70.74	69.08	63.52
" 26.	30.86	31.07	31.66	33.73	36.70	43.80	" 27.	74.88	75.04	74.39	71.79	69.97	63.93
March 5	32.42	32.23	32.59	34.48	37.22	43.59	Sept. 3.	73.41	74.15	73.95	71.92	70.34	64.49
" 12	33.82	34.40	35.10	36.31	38.53	43.67	" 10.	64.10	66.31	67.96	69.11	69.05	* 64.64
" 19	35.00	35.41	35.74	36.85	38.96	43.86	" 17.	58.58	60.24	61.04	63.78	65.06	Bro-ken
" 26	35.23	35.91	36.19	37.27	39.31	43.90	" 24.	63.16	64.03	64.14	63.91	64.03	......
April 2	37.51	37·93	37.76	38.27	39.86	43.99	Oct. 1.	62.26	63.49	63.96	63.84	63.95	......
" 9	41.39	41.50	41.28	40.49	41.19	44.06	" 8.	56.38	58.54	60.01	61.60	62.72	......
" 16	50.60	49.88	48.18	44.99	44.10	43.82	" 15.	54.54	56.46	57.77	59.29	60.71	......
" 23	52.89	52.79	52.07	49.35	47.74	45·18	" 22.	43.66	46.85	49.66	54.46	57.56	......
" 30	55.70	55.81	54.64	51.46	49.81	46.81	" 29.	44.59	46.39	48.09	51.08	54.02	......
May 7.	42.86	44.28	45.81	47.90	49.20	47.99	Nov. 5	44.03	45.78	47.34	49.79	52.39	......
" 14.	51.30	51.25	50.69	48.70	48.40	48.11	" 12.	37.62	40.18	42.85	47.24	50.55	......
" 21.	51.75	51.84	51.67	50.47	49.94	48.56	" 19.	34.44	36.26	38.24	42.77	47.14	......
" 28.	59.97	58.79	57.54	53.81	52.01	49.45	" 26.	32.69	34.96	37.26	41.42	45.12	......
June 4.	63.49	63.16	61.99	57.90	55.42	50.86	Dec. 3.	31.67	33.36	35.23	39.18	43.07	......
" 11.	60.97	60.93	60.47	58.18	56.79	52.38	" 10.	26.01	28.82	31.60	36.86	41.21	......
" 18.	66.62	66.05	64.92	60.92	58.40	53.64	" 17.	25.52	27.26	29.15	34.29	38.94	......
" 25.	73.00	72.46	71.16	66.06	62.54	55.14	" 24.	27.22	28.53	29.79	33.56	37.63	......
July 2.	74.68	74.21	73.54	68.99	65.32	57.04	" 31.	27.90	28.97	30.16	33.41	37.06	......
							Av.....	49.15	49.84	50.31	50.73	51.63	51.47

* Average 6 days.

This set was in grass plat east of railroad until April 9, when removed to point a few rods west of railroad and south of driveway. The latter place has a slight inclination to the south and at first the surface was bare.

TABLE 8.

WEEKLY MEANS OF SOIL TEMPERATURES, SET A. IN DEGREES FAHRENHEIT.

FOR 1899.

Week Ending	DEPTH					Week Ending	DEPTH				
	3 in.	6 in.	1 ft.	2 ft.	3 ft.		3 in.	6 in.	1 ft.	2 ft.	3 ft.
Jan. 7...	23.98	26.41	28.41	32.87	36.54	July 8...	66.83	68.26	68.46	67.01	65.43
" 14..	24.20	26.25	27.80	31.78	35.64	" 15..	67.75	69.10	69.16	67.03	65.58
" 21..	28.97	29.53	30.01	31.77	35.19	" 22..	69.41	70.36	69.85	67.26	65.84
" 28..	29.54	30.36	30.74	32.10	35.09	" 29..	70.64	71.67	71.35	68.72	66.85
Feb. 4...	26.01	27.64	29.19	32.23	35.22	Aug. 5...	68.21	69.27	69.13	67.64	66.68
" 11..	22.38	24.10	26.56	31.58	34.84	" 12..	67.13	68.65	68.71	67.29	66.44
" 18..	25.37	26.51	27.85	31.02	34.25	" 19..	67.32	68·54	68.46	66.99	66.25
" 25..	27.63	28.83	29.76	31.34	34.04	" 26..	66.46	67.26	67.45	66.51	66.06
March 4..	28.85	29.60	29.98	31.34	34.00	Sept. 2...	67.24	68.25	68.19	66.67	66.01
" 11..	31.71	31.47	31.45	31.67	34.11	" 9...	66.11	67.61	67.81	66.71	66.16
" 18..	31.15	31.88	31.74	31.86	34.24	" 16..	61.96	64.20	65.18	65.29	65.52
" 25..	34.59	34.35	33.49	32.94	34.84	" 23..	58.21	60.82	61.89	62.91	63.89
April 1..	31.94	33.08	33.98	35.24	36.78	" 30..	57.34	60.14	61.24	62.01	62.82
" 8..	34.97	35.41	35.27	35.34	36.86	Oct. 7...	53.34	56.66	58.31	60.04	61.49
" 15..	46.06	45.45	43.64	39.99	39.57	" 14..	48.61	51.46	53.92	57.06	59.19
" 22..	48.91	49.82	47.93	44.82	43.71	" 21..	44.25	46.77	48.53	52.49	55.79
" 29..	54.18	57.19	53.34	49.44	47.15	" 28..	44.91	47 24	48.74	51.42	53.81
May 6...	48.16	49.06	49.04	48.17	48.08	Nov. 4...	40.75	43.06	45.09	48.94	51.98
" 13..	55.06	54.94	53.56	50.25	48.95	" 11..	40.26	42.35	43.85	46.93	49.99
" 20..	58.84	59.01	58.03	54.39	52.15	" 18..	39.54	41.56	43.16	45.99	48.89
" 27..	58.31	58.67	58.08	55.44	53.85	" 25..	35.85	38.41	40.91	44.41	47.59
June 3...	60.41	60.84	59.97	57.06	55.41	Dec. 2...	36.69	38.48	39.75	42.64	45.93
" 10..	60.39	61.09	60.36	57.69	56.27	" 9...	31.02	33.84	36.08	40.89	44.69
" 17..	64.14	63.86	62.40	59.22	58.29	" 16..	30.21	32.24	34.14	38.69	42.71
" 24..	67.40	68.20	67.06	62.98	60.86	" 23..	29.09	30.96	32.56	36.99	41.08
July 1...	71.08	71.59	70.51	66.57	63.91	" 30..	30.08	31.51	32.62	36.11	39.95
						Average .	47.18	48.53	48.94	49.30	50.32

TABLE 9.

WEEKLY READINGS (not averages) OF SOIL THERMOMETERS, SET C.
(On unirrigated ground).

FOR 1898.

Date	DEPTH 6 in	1 ft	2 ft	3 ft	Date	DEPTH 6 in	1 ft	2 ft	3 ft
January 6	29.1	29.6	33.8	36.3	July 7	71.7	67.9	64.5	60.9
" 13	25.6	27.1	32.8	35.3	" 14	73.4	70.2	66.4	62.8
" 20	24.5	25.6	31.0	33.8	" 21	72.7	70.4	67.6	63.9
" 27	23.0	24.5	30.3	33.3	" 28	75.2	71.9	69.1	64.9
February 3	25.7	26.3	30.4	32.8	August 4	71.9	69.4	67.8	65.1
" 10	31.4	30.6	31.3	33.1	" 11	70.2	68.1	68.3	64.4
" 17	32.1	31.9	33.3	34.0	" 18	71.1	68.9	67.4	64.8
" 24	30.1	30.6	33.4	34.3	" 25	72.0	69.6	68.1	65.4
March 3	32.6	32.6	34.2	34.8	September 1	72.4	70.6	68.7	65.7
" 10	34.2	34.0	35.3	35.8	" 17	60.1	59.2	60.8	60.8
" 17	33.1	33.7	35.6	36.2	" 22	62.1	60.5	60.9	60.2
" 24	32.6	33.2	35.3	36.3	" 29	61.6	60.6	60.9	60.0
" 31	35.8	34.6	35.8	36.2	October 8	55.0	55.0	57.8	58.3
April 7	40.2	38.6	38.4	38.9	" 13	54.2	54.5	56.8	56.8
" 14	48.7	45.0	42.6	40.6	" 20	43.6	46.5	52.6	54.4
" 21	51.7	49.5	46.8	44.0	" 29	45.2	45.6	49.1	50.9
" 28	54.2	51.9	49.8	46.5	November 3	42.2	43.2	48.0	49.8
May 5	39.7	41.1	45.2	46.0	" 10	39.1	41.2	46.3	48.3
" 12	52.1	50.1	48.2	46.0	" 17	35.2	36.9	42.7	45.6
" 19	52.2	50.8	49.8	47.9	" 25	32.7	35.3	40.9	43.8
" 26	58.4	56.6	53.7	50.3	December 1	31.7	34.8	39.6	42.2
June 2	63.2	60.0	56.7	53.1	" 8	26.7	29.5	36.3	39.9
" 9	62.1	59.6	57.1	54.1	" 15	23.2	25.2	32.4	36.6
" 16	65.7	62.2	59.1	55.8	" 22	25.3	27.0	32.1	35.1
" 23	68.7	65.5	61.8	58.0	" 29	28.5	28.3	31.7	34.3
" 30	72.0	68.2	64.0	60.0					
					Average	47.8	47.1	48.3	48.0

This set of thermometers is placed on a knoll near the farm barn, unirrigated.

TABLE 10.

WEEKLY READINGS (not averages) OF SOIL THERMOMETERS, SET C.
(On unirrigated ground).

FOR 1899.

Date	DEPTH				Date	DEPTH			
	6 in.	1 ft.	2 ft.	3 ft.		6 in.	1 ft.	2 ft.	3 ft.
January 5.....	23.7	26.2	31.4	34.1	July 6........	66.8	64.8	62.6	59.9
" 12.....	23.9	24.0	29.4	33.7	" 14........	67.5	65.6	63.7	60.8
" 19.....	28.2	27.6	30.3	32.5	" 20........	68.8	66.2	64.0	61.2
" 26.....	28.2	28.3	31.2	33.1	" 27........	69.4	67.4	65.0	62.1
February 2....	26.2	27.7	31.4	33.0	August 3......	68.5	66.8	64.6	62.0
" 9....	21.6	21.6	28.0	32.6	" 10......	67.2	65.7	64.5	62.3
" 16....	24.7	24.6	27.9	......	" 18......	67.7	65.9	64.7	62.5
" 23....	23.5	23.8	27.7	......	" 24......	66.3	65.0	64.3	62.2
March 2.......	32.2	30·1	32.8	......	" 31......	67.8	66.2	64.9	62.8
" 9.......	32.9	32.0	32.8	33.1	September 7...	59.7	66.4	64.9	62.8
" 16.	32.5	32.2	32.8	33·8	" 14...	65.6	63.9	63.5	62.0
" 23.......	32.7	32.6	33.7	34.1	" 21...	60.1	59.5	61.0	60.7
" 30.......	33.2	33.1	34.3	34.5	" 29...	57.7	58.1	59.8	59.3
April 6........	33.2	33.0	34.1	34.6	October 5.....	55.0	55.3	58.3	58.4
" 13........	45.5	42.0	38.4	34.7	" 12.....	52.2	52.0	55.5	56.1
" 20........	44.2	42.6	41.9	40.2	November 2...	40.2	42.0	47.0	49.3
" 27........	52.0	48.8	45.8	43.1	" 8...	41.2	41.1	45.0	47.3
May 4........	46.5	44.7	45.5	44.4	" 9...	40.7	41.1	44.5	47.1
" 11........	54.2	50.6	47.8	45.8	" 16...	41.4	41.0	43.8	45.7
" 18........	55.7	52.7	50.8	48.5	" 23...	38·9	39.1	42.5	44.6
" 25	59.2	55.5	52.3	49.8	December 1...	38.0	37.7	40.8	42.8
June 1........	53.4	56.2	54.1	51.6	" 7...	33.2	34.5	38.9	41.5
" 8........	59.1	57.1	55.0	52.7	" 14...	32.2	33.3	37.3	39.8
" 15........	62.8	59.7	57.3	54.4	" 21...	29.7	31.7	35.9	38.6
" 22........	65.2	62.7	59.8	56.5	" 28...	31.1	31.6	35.1	37.5
" 29........	70.2	65.9	61.9	58.4					
					Average	46.99	46.22	47.07	47.93

TABLE 11.

DATES OF EXTREME TEMPERATURES AT DIFFERENT DEPTHS FROM READINGS AT 7 A. M. AND 7 P. M. SET A.

Year	DEPTH											
	3 INCHES				6 INCHES				12 INCHES			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	June 30..	87.7	Jan. 9...	16.0	July 1...	81.2	Jan. 9...	21.0	June 30..	76.8	Jan. 21–22	26.0
1890	July 1...	86.2	" 2...	14.5	" 1..	81.2	" 2...	20.0	July 16..	72.5	" 24..	25.5
1891	" 24..	84.0	Feb. 9...	17.8	" 11..	80.6	Feb. 2...	21.9	....	..	....	....
1892	Aug. 24..	84.2	Jan 13..	16.3	Aug. 14..	80.8	Jan. 11..	20.7	Aug. 15..	72.5	....	....
1893	June 28 to July 4	87.5	" 18..	21.3	July 5...	83.9	" 18..	26.0	July 5...	76.1	Jan. 21..	30.3
1894	June 12..	78.6	Dec. 28..	14.7	" 27..	76.1	Dec. 28..	21.4	" 27..	71.5	Dec. 28..	24.3
1895	July 6...	83.2	Jan. 15..	8.5	" 6...	78.8	Jan. 15..	13.0	" 29..	71.6	Jan. 15..	19.2
1896	" 13..	90.8	" 4..	18.8	" 13..	86.1	" 4..	22.7	" 13..	77.1	" 4...	27.9
1897	" 7...	78.2	" 5...	18.9	Aug. 12..	77.3	" 5...	23.9	Aug. 12..	77.0	" 5...	29.5
1898	" 15..	85.4	Dec. 14..	20.0	July 17..	82.2	Jan. 27 to Dec. 14.	24.7	¶ July 19..	77.7	" 27..	28.0
1899	June 28..	84.3	Jan. 10..	18.8	June 28.	79.2	Feb. 8...	21.6	" 24..	73.9	Feb. 7...	25.3

Year	DEPTH											
	2 FEET				3 FEET				6 FEET			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	July 18..	67.3	Jan. 28..	30.9	Aug. 19..	64.6	Jan. 29–31	33.3	Sept. 5–10	60.0	Mar. 3...	39.2
1890	" 17 27 28	66.9	Feb. 11..	30.6	" 21..	64.6	" 29...	33.3	" 1–12.	60.0	Feb. 18..	39.4
1891	Aug. 7... July 26..	68.7	" 14 16 17	32.1	" 16 17 19 20.....	65.6	Feb. 19 22 23 26.....	34.0	" 17...	63.8	Mar. 12–23	39.0
1892	Aug. 17..	68.7	Jan. 24–25	31.4	Aug. 18..	65.5	Feb. 28..	33.6	" 1...	60.2	Feb. 24–26	39.6
1893	* July 6...	75.3	" 22...	32.6	July 24..	67.6	Jan. 23–27 Feb. 11..	34.8	† July 6...	67.4	" 21 22–25	40.2
1894	June 28..	69.8	Feb. 25..	31.5	‡ June 28..	69.7	" 27 28	33.5	‖ June 28..	64.4	Mar. 15..	38.5
1895	Aug. 2...	68.0	Jan. 16..	27.5	Aug. 7–8.	65.9	Jan. 18..	32.8	Aug. 30–Sept. 19.	61.0	" 1...	39.3
1896	" 15–17	71.9	" 6..	31.6	" 16–17	69.5	" 8 17 18	35.5	Aug. 24–25	62.8	Feb. 17–22	41.0
1897	" 12..	§ 76.1	Feb. 2..	32.4	§ " 17...	73.6	Feb. 2–10	35.5	§ Aug. 16..	75.5	Mar. 24–Apr. 2...	41.0
1898	July 30..	73.0	Jan. 28–Feb. 12..	33.0	Sept. 1..	70.6	" 7–20	36.5	Sept. 5–6	67.5	Apr. 10..	43.4
1899	" 26–28	69.1	" 15..	30.9	July 28..	67.2	" 23–Mar. 1...	34.0	....	....	....	....

* Water applied to lawn 69.2 July 31 was probably highest otherwise.
† " " " " 62.6, Sept. 11–13.
‡ July 31, 68.5, unaffected by water.
Aug. 22, 66.7.
‖ Sept. 2, 62.5.
§ Affected by irrigation.
¶ 74 June 29 after watering grass.

Observations made at 2 and 9 p. m., before July 1, 1889. 6 feet thermometer broken Sept. 10, 1898.

TABLE 12.

EVAPORATION FROM WATER SURFACE, TANK 3x3x3 FEET, FLUSH WITH GROUND, AT FORT COLLINS, COLO.

(In inches.)

Latitude 40° 34′; Longitude 105°+; Elevation 4,980 feet.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1887	2.46	3.23	4.60	5.55	5.19	5.75	5.23	4.24	4.12	3.26	1.48	1.60	46.71
1888	....	....	....	....	4.45	† 7.70	† 7.00	4.06	3.94	2.17	1.35	0.99	......
1889	1.08	1.03	2.75	4.06	3.72	4.34	5.20	5.15	5.19	3.28	0.62	1.42	37.84
1890	0.86	2.36	3.58	3.50	4.32	5.71	5.44	5.76	3.69	2.71	1.32	1.10	40.25
1891	* 1.89	1.90	2.23	2.24	5.03	4.97	5.72	4.91	4.12	3.62	1.74	0.75	39.12
1892	2.51	‡ 2.15	2.78	3.58	3.49	4.20	4.69	5.64	5.11	3.33	1.93	1.13	40.54
1893	P	* 1.52	3.79	5.40	5.12	6.12	6.41	4.73	5.04	3.79	1.05	1.88	......
1894	† 1.14	† 1.15	1.95	4.61	4.66	5.01	5.74	4.88	3.77	3.75	1.64	1.22	39.52
1895	† 1.19	† 1.19	P	4.91	4.27	4.13	4.57	4.52	4.06	2.24	1.53	1.68	......
1896	2.64	2.25	2.39	4.71	5.91	5.09	5.23	5.80	3.34	2.94	1.62	1.25	43.17
1897	1.80	2.20	P	3.33	4.13	4.26	4.64	4.76	3.97	2.88	1.47	0.94	......
1898	1.12	* 1.31	2.53	4.65	3.90	5.67	7.33	6.57	5.57	4.64	1.36	0.67	45.32
1899	§ 1.51	§ 1.39	§ 1.54	3.19	5.35	6.37	5.38	5.86	5.04	2.87	1.86	1.15	42.11
Average	1.65	1.81	2.81	4.19	4.58	5.33	5.58	5.14	4.38	3.79	1.46	1.18	41.30

* Based on record for part of month.
† From Record of two months.
‡ From record from February 17.
P Tank punctured, record lacking.
§ From record of three months.

TABLE 13.

RAINFALL AT THE AGRICULTURAL COLLEGE, FORT COLLINS, COLO.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1872	....	....	...	....	...	....	....	....	....	....	0.02	0.20	......
1873	0.25	0.16	0.00	1.20	2.30	1.50	1.30	0.85	0.75	0.42	0.20	0.17	9.10
1874	0.06	0.43	1.29	0.77	2.95	0.65	3.15	0.25	0.00	1.00	0.02	0.00	10.40
1879	....	...	....	....	....	....	....	....	....	1.75	0.15	0.60	......
1880	0.72	[illegible]	0.38	0.94	0.60	0.86	1.80	0.37	1.47	2.07	....	0.10	......
1881	1.10	0.55	1.45	....	....	....	....	....	....	....	....	....	......
1882	....	....	0.17	....	1.67	3.07	1.76	0.89	2.51	0.82	0.29	....	......
1883	1.60	1.50	0.68	....	2.51	3.18	....	1.78	1.00	1.29	T	1.33	......
1884	1.10	0.70	1.15	3.94	4.84	....	....	....	....	0.10	1.80	0.35	......
1885	1.77	...	....	....	....	....	....	....	....	....	...	....	......
1886	....	...	....	....	....	....	....	....	....	0.69	1.18	0.33	......
1887	0.86	0.23	0.25	1.10	1.23	1.96	3.05	2.12	0.54	0.43	0.15	0.00	12.12
1888	0.29	0.36	0.73	1.23	3.39	0.47	0.60	1.01	0.29	0.88	0.38	0.16	9.79
1889	0.21	0.34	0.65	2.67	3.39	2.06	0.79	0.95	0.42	3.16	0.43	0.01	14.48
1890	0.13	0.21	0.22	3.92	1.19	0.12	1.27	3.14	0.07	0.70	0.32	0.12	13.58
1891	2.32	0.16	1.21	2.14	4.07	1.30	0.17	2.05	1.01	0.20	0.60	0.46	15.69
1892	0.60	1.29	1.52	1.60	4.83	2.42	1.32	0.22	0.14	0.93	0.23	0.01	15.45
1893	0.02	0.54	0.14	1.66	[illegible]	0.26	0.64	0.92	0.18	0.16	0.55	0.12	7.11
1894	0.25	0.60	0.67	0.89	3.09	0.42	1.72	1.53	2.29	T	0.14	0.76	12.36
1895	0.24	1.52	0.54	1.36	3.62	3.65	3.75	1.45	0.47	1.06	0.40	0.01	18.07
1896	0.43	0.03	1.73	1.26	1.68	3.05	3.05	2.20	1.55	0.49	0.05	0.24	15.76
1897	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
1898	0.14	0.08	0.50	1.08	3.65	1.37	0.50	0.98	0.50	0.82	1.24	0.17	11.03
1899	0.66	1.04	1.50	1.10	1.01	1.03	4.95	0.99	0.21	3.23	T	0.47	16.19
Normal	0.62	0.60	0.85	1.63	2.79	1.61	1.91	1.30	0.79	1.00	0.42	0.32	13.84

TABLE 14.

PRECIPITATION 1898.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Pinkhampton.........	0.45	0.52	1.30	0.33	2.10	0.66	0.50	0.82	0.15	1.51	2.10	1.50	11.94
Lambs	0.40	0.45	0.59	1.73	1.82	2.05	2.9[illegible]	1.53	0.81	0.60	1.60	0.60	15.13
Gleneyre	0.40	0.10	0.60	1.20	1.60	0.70	0.70	0.30	0.50	0.95	1.20	——	——
Shetland Ranch.......								1.02	0.44	1.55	2.60	1.40	——
Waterdale.............	0.24	0.25	0.87	1.42	3.43	1.86	1.20	1.61	0.50	0.75	1.62	0.50	14.25
Fort Collins...........	0.14	0.08	0.50	1.08	3.65	1.37	0.50	0.98	0.50	0.82	1.24	0.17	11.03
Rocky Ford...........	0.40	0.0	0.16	1.06	2.71	3.16	3.52	0.92	1.55	1.36	0.37	0.96	16.17
Cheyenne Wells.......	0.03	0.0	0.61	1.10	5.55	3.95	2.09	1.33	2.00	0.48	0.50	0.48	18.13

PRECIPITATION 1899.

Pinkhampton.........	3.33	3.60	2.60	1.60	0.27	0.60	1.18	0.91	0.30	3.09	T	1.17	18.65
Lambs	0.52	1.05	2.97	1.10	0.38	1.69	3.32	1.73	0.11	2.31	0.03	0.62	15.23
Shetland Ranch.......	3.13	3.87	1.20	0.13									
Waterdale.............	0.53	1.10	1.25	0.84	0.67	0.92	2.12	0.94	0.19	3.30	0	0.49	12.35
Fort Collins...........	0.66	1.04	1.50	1.10	1.01	1.03	4.95	0.99	0.21	3.23	T	0.47	16.19
Rocky Ford...........	0.98	0.55	0.32	0.28	0.99	0.78	7.00	2.22	1.43	0.63	2.40	0.98	18.56
Cheyenne Wells.......	0.47	0.36	0.39	0.03	2.88	1.89	3.67	0.55	0.79	T	2.49	0.55	14.07

Pinkhampton for Jan., Feb., March. Dec., 15 in. snow taken for 1 in. rainfall.

15 in. of snow taken for 1 in. rainfall at Shetland Ranch for Jan., Feb., March and April.

Shetland Ranch is near Home Postoffice on the Poudre River; elevation 7800 feet. John Deaver, observer.

Waterdale is on the Big Thompson, in the foothills west of Loveland. P. H. Boothroyd, observer.

INDEX.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 41.

BLIGHT AND OTHER PLANT DISEASES.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

FEBRUARY, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

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Fort Collins, Colorado.

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THE AGRICULTURAL EXPERIMENT STATION,

FORT COLLINS, COLORADO.

BLIGHT AND OTHER PLANT DISEASES.

BY C. S. CRANDALL.

BLIGHT OF APPLE AND PEAR TREES.

Discussion of the disease known as blight is approached with some trepidation, and is only undertaken in response to what seems to be a growing demand from fruit growers for information concerning the disease. It has been present in the state for ten years, but never before have letters of inquiry and appeals for aid been so numerous as during the past summer.

It should be remarked at the outset that I have nothing new to offer regarding the disease or its treatment, but shall simply attempt to bring together the main historical facts, and epitomize the work that has been done by those who have given the disease exhaustive study.

Pear-blight, apple-blight, fire-blight, twig-blight are all names for the same disease; a disease which has proven the most destructive of any of the plant maladies with which the horticulturist has ever had to deal. It is not a new disease; it has been known and dreaded for at least a hundred years. The early horticultural journals abound in articles on the subject, and horticultural societies, ever since their inception, have found it a constant subject for discussion. But writing about it and discussing it failed to eliminate the disease or to make plain its cause. Discussion became so barren of results that the Western New York Society resolved that the subject should not be broached unless some one had something entirely new concerning the disease to communicate.

As with all phenomena arising from causes unknown and therefore mysterious, pear-blight offered abundant opportunity for the theorist. Theory after theory was put forth; some based upon the observations of practical men,

and some on pure conceptions of the mind. Every theory as to the cause prescribed a remedy based upon the theory. These remedies were put to trial and reported on; reports varied. Two men would report the use of a remedy under similar circumstances; one with favorable results, the other with adverse results. The next season the same men using the same remedy in the same way would reverse their reports. Success one year would be counterbalanced by failure the next, and the remedy would be laid aside as useless.

Many of the successes with various remedies as reported in the older journals, we can now see were simply successes reasoned from negative results. A man has a tree affected with blight, he cuts off the blighted limbs, applies a wash of copperas over the tree, the blight progresses no further, and he reports a cure effected by washing with copperas. His experiment is worthless; had he allowed the blighted branches to remain on the tree, and applied the copperas, with an arrest of the disease as a result, then his report would have been warranted. But as he reported, might not his accredited cure have been due to the complete removal of the disease with the infested branches which he cut off? And just so with a great number of experiments tried with other remedies. They were of no value because conclusions were hastily drawn from only a part of the attending circumstances.

THEORETICAL CAUSES.

Among the numerous assigned causes of pear-blight I may mention the following. 1-Electricity and atmostpheric influences. 2-A stroke of the sun. 3-Old age, or a long duration of varieties. 4-A sudden freezing of the bark. 5-The freezing of the roots wherby absorption is prevented, and, the supply of moisture being cut off, the evaporation from the branches caused blight. 6-Too high culture. 7-The absence of certain mineral matters in the soil. 8-Insects. 9-Fungi. 10-An epidemic transmitted from place to place by the air.

Each of the above theoretical causes had a following, but most of them were entertained for a brief period only, because observed facts made the theories untenable, and wherever any one of these theories was put to the test of actual experiment it was quickly shown to be fallacious.

DOWNING'S FROZEN-SAP THEORY.

The most widely accepted of the early theories was that

advanced by A. J. Downing in the first edition of his "Fruits and Fruit Trees of America" which appeared in 1845. The name "Frozen-sap blight" was there applied to the disease. The theory being that the disease was due to freezing and thawing of the sap which thus lost its vitality, became dark and discolored, and poisonous to the plant. He says a damp warm autumn, followed by a sudden and early winter, always precedes a summer when blight is very prevalent.

In enumerating the symptoms of the disease, Mr. Downing gives just those characteristic features with which every one who has come in contact with the disease is familiar. The thick gummy exudation from diseased tissue, the dark, discolored areas of bark that follow attacks upon the trunk and branches, and the sudden blackening of growing extremities in early summer.

No fault can be found with all that Mr. Downing says of symptoms, and of circumstances attending the disease; but he was wrong in many of the conclusions drawn, and in the wide application he makes of conditions that prevailed only locally. Of remedies Mr. Downing says: "The *most successful remedies* for this disastrous blight, it is very evident, are chiefly preventive ones" . . . . "As a remedy for blight actually existing in a tree, we know of no other but that of freely cutting out the diseased branches, at the earliest moment after it appears."

In July, 1846, Mr. Downing began the publication of the "Horticulturist," a monthly journal of "Rural Art and Rural Taste," and in the second, or August number of that journal he writes at length of the blight, repeating the theory as advanced in his work of the year previous.

OBJECTIONS TO THE FROZEN-SAP THEORY.

In the December number for the same year, place is given for an article by a correspondent from Terre Haute, Indiana, who signs himself S. B. G. This writer presents a number of observations which appear as valid objections to the frozen-sap theory, some of which I desire to quote. "If this theory be true, why have its effects manifested themselves so recently? Our climate has undergone no change. The vicissitudes of weather have never been less than now. I have resided upon the Wabash more than twenty-three years and have known no difference in this respect. I have known almost whole winters that the plow might have run, while others have been cold. Late spring frosts, and late, warm, humid fall weather, have always marked our fitful

climate, yet was the pear blight never heard of until recently."

The prevalence of blight in 1845 was ascribed to a frost occurring on the tenth of May. This writer cites a much more severe frost on the same day of the year 1834, but there was no blight that year.

A further objection refers to the effect of frost upon sap. "The freezing of sap does not change its properties. That the freezing of vegetable matter in a certain state of development produces death, may be admitted."........"It may also be admitted that the freezing in winter may be so severe as to destroy the vital principle as well in vegetable as animal life."........"Death thus produced is not occasioned by deleterious properties imparted to the sap, but by the mechanical force of the frost upon the cellular and woody tissues." ...."All our trees are frozen, except their trunks and large branches, every winter, especially the young and tender wood of the past summer's growth, and if an elaboration of the sap injurious in its consequences were thereby produced, no vegetable matter would survive a single winter. The economy of the vegetable world rests not on so insecure a basis as this would indicate." This writer here speaks of the spread of the disease in the individual plant, and cites a case of the production of the disease in a healthy tree by inoculation from a diseased tree. Further he says: "There is no occasion to theorize upon this subject for the mere sake of theory, and I have none that I regard as certainly true; but I strongly incline to the belief that the pear blight is an *epidemic*, that it prevails like other epidemics, and will pass off like them. The atmosphere is, I believe, generally admitted to be the medium by which they prevail, and are carried from place to place. What that subtle principle may be, which pervades our atmosphere, by which infection is retained and transmitted, so that, like the Asiatic cholera, it makes the whole circuit of our earth, human science has not discovered, and perhaps never will; but that such a principle exists, is sufficiently obivious from its effects."

Looking back in the light of what "human science" in the modern times has discovered, to those days when the germ theory was little more than a suggestion, the statement above quoted is of interest.

CAUSES SOUGHT IN ATMOSPHERIC AND SOIL CONDITIONS.

The writers for the agricultural press of fifty years ago were much inclined to look for causes of the disease in the attendant atmospheric and soil conditions. One writer in 1851 says: * "A fruit tree planted on a well-drained poor

* Patent Office Report. Agriculture. 1851 page 403.

soil will seldom suffer from blight of any kind. Too much trimming, too much moisture, and too rich soils are, in my opinion, some of the causes of blights in apple and pear trees. I believe there are several varieties of blights in apple trees and probably in pear trees also. I think I am in posession of facts and observations which will explode all the blight theories which I have seen published." This gentleman certainly observed some of the conditions which may aggravate blight, but his was as far from the true cause as any of the blight theories he thought himself able to explode.

FUNGI.

The man who introduced the theory of a fungus origin of the disease was for a considerable time quite safe from contradiction. Many fungi are very small; to learn anything of them beyond the fact of their existence requires a microscope. They had then received little attention, little was known of them, and it was impossible to prove or disprove their casual connection with the disease.

An investigator in 1872 ascribes the disease to a local fungus fermentation of the genus Torula and he observes that * "Every condition that will prevent the bark and shoots from ripening will foster under high temperatures, in the presence of organic acid and vegetable nitrogenous matter, one or more species of Torulacei fungi." And he further infers that contamination may come about by the absorption of the fungus germs by the roots, and in this case the fermentation proceeds from the sap-wood to the exterior. Drainage, or the removal of the tree to a more favorable place is recommended. The writer speaks of another form of the disease where the fermentation proceeds from the surface to the interior. This he calls atmospheric blight. Now beyond the fact of the presence of fungi in the diseased tissues this was all theory.

In 1875 Thomas Meehan, editor of the Gardener's Monthly, in speaking of the researches of Dr. Hunt of Philadelphia, says he finds "That a very minute fungus germinates in the outer bark, enters the structure, destroying the cells as it goes, till it reaches the alburnum, and then it penetrates clear to the pith, by the way of the medulary rays, totally destroying the branch from center to circumference;" and he adds, "There is no other conclusion here than that arrived at by Dr. H., that in the true fire blight, fungi are the cause of the disease."

It was an easy matter to find fungi in the dead tissues

* Department of Agriculture Report 1871, page 191.

of trees affected by blight, and their presence there was considered as sufficient evidence that they caused the disease. No crucial test was ever applied to prove that causal action. So in the absence of positive proof, all the claims of discovered cause made, up to this time were valueless.

DISCOVERY OF THE TRUE CAUSE.

The first light shed upon what has since been proved to be the true cause of pear blight was in 1878 when Professor Burrill of Illinois announced to the Illinois State Horticultural Society the discovery of bacteria apparently connected with the disease. The germ theory of disease had been under discussion for several years, and, previous to this time Pasteur had (in 1869–70) demonstrated that a microbe caused the terrible silk-worm disease, and later in 1876 that splenic fever and fowl cholera were also due to the action of specific microbes. Professor Burrill was the first to suggest that these low organisms might be connected with plant diseases. In his announcement in 1878 he made no positive assertion, but simply reported discoveries which were sufficient foundation for a very strong suspicion that these organisms did cause the disease. Continuing his investigations of the subject, in 1880 he had advanced far enough to announce before the American Association for the Advancement of Science that he had discovered the cause of pear blight. That the cause was a specific organism, for which he proposed the name Micrococcus amylovorus. Professor Burrill rested his claim upon the results obtained in a series of experiments. He inoculated healthy pear and apple trees with diseased tissue, and, in a large number of cases, blight followed the inoculation. The process of inoculation was both by the transfer of small pieces of diseased bark, and by pricking with a needle dipped in macerated diseased tissue. His results would seem to warrant his assertion that blight was caused by the organism which the microscope showed was present in large numbers. But in the light of modern methods of experiment, his proof could not be considered as absolute.

Investigators of the etiology of the contagious diseases of animals, agree, that in order to prove positively that any suspected organism is the specific cause of any particular disease, four steps are necessary. These steps which were first recognized, enumerated, and published by Professor Cohn, are as follows:

1. To demonstrate the habitual presence of the organism in cases of the disease in question.

2. To find some medium outside the animal body, in which this organism will live and multiply.

3. To cultivate the organism in this medium for a sufficient number of generations to insure the complete elimination of other organisms that may have been introduced into the first cultivation; in other words, to secure a pure cultivation of the organism.

4. To inoculate a healthy individual from the pure culture of the organism, and produce the original disease.

These steps carefully followed, afford a means of proof that, it seems to me must convince the most skeptical. This method of proof is just as applicable to plant diseases as to animal, and in the case of pear blight it remained for Professor Arthur, then of the New York experiment station at Geneva, to apply it. This he did during the seasons of 1884 and 1885.

WORK OF PROFESSOR ARTHUR.

Professor Arthur used as a culture medium a tea made by steeping corn meal in water and then filtering until a clear infusion was obtained. In this medium he cultivated the organism for a number of generations. Trees inoculated from his last culture, which contained Micrococcus amylovorus, and no other organism, developed the disease. Here was good proof that this specific organism caused pear blight; but there was one question that might be raised. Might not the liquid in which the organism lived be the exciting cause, instead of the organism? To prove this point a culture containing the organism was filtered through porcelain. The clear liquid, which upon examination by the microscope was shown to be free from germs, failed in every case to communicate the disease, but the residue of germs, left after filtering, when used to inoculate healthy trees, readily produced the disease. Thus by the method of experiment has every doubtful point been covered, and the fact established beyond controversy that this particular organism, Micrococcus amylovorus, is the true cause of pear blight, or apple blight.

This demonstration did not at once meet with universal acceptance. Various objections were raised to it. There were many men who refused to accept as the exciting cause something they could not readily see, something which could not readily be made evident to the senses. The observation and study of these low organisms, and of the tissue in which they live must be carried on under high powers of the microscope; they must be magnified at least

1,000 diameters. It is only men trained in the use of the microscope that can carry on observations under these conditions. The growth of an organism in a culture fluid is readily observed by the naked eye, by reason of its action on the fluid, and the results obtained by inoculation are easily seen. These two points must serve to inspire confidence in the statements of the microscopist regarding what takes place beyond the range of natural vision. The specific name, amylovorus, given by Professor Burrill, to this organism, means starch-devouring, and was given because the removal of starch from the cells appears to be the work they perform. In the process, which is a true fermentation, carbon-dioxide is given off, and butyric acid is formed.

EPIDEMIC NATURE OF THE DISEASE.

Like all diseases which have been traced to an origin in low forms of life, pear blight is epidemic in its character. During certain seasons it is very destructive; this extreme virulence may last two, three, or four years, then the disease will decrease, or possibly pass away entirely, to appear again after a long interval.

Charles Downing says, in speaking of his locality: "Pear blight has appeared at intervals of about twenty years, and the duration of each has been from three to five years. I have passed through three of these periods, and with each additional visit the attack is very much lighter; and like many other diseases it may run itself out in time." Mr. Downing's statement was made before the true cause of the disease was known. There does seem to be a periodicity connected with the disease, and while we are likely to have intervals of immunity, I have no faith in its finally running out.

MEANS ON DISSEMINATION.

How does the disease get into the tree, and how is it carried from one tree to another? First as to its dissemination. Whether the germs of the disease are carried in the air or not has not yet been satisfactorily demonstrated, but it is well known that insects carry the disease, and that in them we have the chief means of its dissemination. The gummy exudation already alluded to, which is commonly present in cases of attack upon the trunk or larger branches, is shown by examination to consist of myriads of the living organisms, held together by the viscid secretion which seems so characteristic of their work. This exudation is most abundant in the spring after the tree has started into full

activity. It is attractive to insects, and they by their frequent visits disseminates the organisms rapidly at a period when the opportunities for their easy access to healthy plants are best.

HOW THE GERMS GET INTO THE TREE.

Now as to the method of gaining access to the tree. The virus of the disease spread upon healthy bark will not communicate the disease; this has often been proved by experiment. The microbe is incapable of penetrating healthy bark; but prick the bark with a fine needle smeared with the virus and you can produce the disease. The puncture or wound, no matter how small, is large enough to afford access to the germs which at once find themselves under conditions that will promote their growth. Wounds in the bark then, afford one means of access to the disease. Most cases of blight on the body of the tree originate in this way, certainly all those that show only isolated diseased areas, and in many of these cases the fact that the disease has spread from a central point of infection is very apparent. Last season portions of the trunks of several trees, ranging from one and one-half inches to two and one-half inches in diameter were sent us from an orchard near Canon City. Each piece bore from one to four elliptical areas of bark dead from blight, and in each case it was very plain that the disease had spread from a center; the center being a point where a starting shoot had been rubbed off. This would point to a need for some application following the removal of adventitious shoots to prevent the access of the blight organisms.

During the winter season, fully formed bark envelops the whole tree, forming an impervious protective against the disease, so at this season the only means of access would be by wounds. But as the buds push in spring we have presented other vulnerable points. The young shoots are soft and succulent, they have no covering capable of resisting attack, as has been often demonstrated. When the flowers expand we find in the flower cup, parts that are even less protected than are the youngest shoots. The stigma and nectaries offer conditions most favorable to the development of the organism.

Insects are no doubt responsible for the first infection, and in their busy flight from one flower to another during the whole period of flowering they disseminate the disease from one tree to another, and from orchard to orchard. It has always been observed of the disease that the twig-blight

form was most common shortly after the blooming period, and the reason seems apparent.

The points of access are then three in number. The flower, the young and growing shoots, and wounds in the bark.

CONDITIONS WHICH AGGRAVATE THE DISEASE.

It remains for us to consider briefly the conditions which may aggravate the disease and what may be done to check or prevent it. It is a matter of common observation that the disease varies greatly in different localities and in different seasons. It may progress slowly or with great rapidity. Knowing as we do now, the cause of the disease, and the conditions under which the organism most rapidly propagates, we can account for this variation by the different conditions prevailing. The old theory that rich soils, and moisture were the cause of the disease was a favorite one, and undoubtedly arose from the observation that on rich soil, and in moist seasons the disease was most virulent and destructive. Rich soils with accompanying moisture is conducive to rank, rapid growth. The tissues formed are gorged with sap, and are very succulent. In this condition of things, we find all that is necessary for a rapid growth of our microbe. On a soil of only moderate fertility the growth is slow, less succulent tissue is produced, and if the supply of moisture is small, we have conditions not advantageous to the organism, and its development is slow. In this matter of growth we find a reason for the various opinions regarding clean culture, or grass in the orchard. One man has no blight and attributes his escape to clean culture. Another has no blight and thinks it is because his orchard is in grass. Both may be right, though the reasons they give for the immunity are wrong. An orchard on rich soil may receive just the necessary check in growth to prevent too great succulency by having grass in the orchard. An orchard on poor soil may need the clean culture to keep it in healthy growth. Anything then, whether in the choice of soil or manner of treatment that gives the trees a slow growth which will thoroughly ripen and harden, will render them less liable to attack from blight. Close planting is objectionable, because the ground being too much shaded, moisture is retained, and moisture favors blight.

In irrigating, care should be taken not to apply an excessive amount of water. I believe the general tendency is toward the use of too much water, and that by this means that succulent growth so readily attacked by blight is induced.

Water should only be applied when needed, and the need is easily discovered by careful examination of trees and soil.

TREATMENT.

From the nature of the disease, it is evident that when it has once gained access to the tree, preventive applications are useless.

The organism is secure in the cell tissue beneath the outer bark; you cannot reach it with any germicide yet known. There is therefore, but one remedy, and that is to cut and burn the infested portion of the tree. If trees are closely watched and diseased portions removed as soon as discovered, the difficulty may be checked without serious injury to the tree, but if allowed to spread until the amputation of large limbs becomes necessary the tree will be deformed if not entirely ruined. In years when the disease is extremely virulent, this work of cutting out is discouraging, and this has led some to object to the practice. Objections have also arisen from those who were unsuccessful because of careless and imperfect work. There is, however, abundant testimony from many sources that it pays to follow the practice closely and persistently. There is no other way of holding the disease in check after it has once started.

In cutting out twig blight it is hardly practicable to protect the cut surfaces; but where branches one-half inch and upward in diameter are removed, and particularly where the bark is cut away from blighted areas on the trunk and larger limbs, the cut surfaces should be at once covered with some protective coat. Lead and oil paint, shellac wash, and various forms of grafting wax, have all been used. I prefer the paint because it is cheaper, and less liable to crack and fall away under the drying action of the sun.

In cutting out blighted portions there is one precaution that should always be observed, and that is the sterilization of the knife after each cut; if this is not done, germs may be left upon the cut surface of the branch and the disease will continue to spread.

The sterilization of the knife may be effected either by passing through a flame or by immersion in carbolic acid or other germicidal solution. In cutting, it should of course, be the aim to cut safely below the diseased part. The limit of the disease is not the well marked line of dead tissue. It is not in the dead tissue that we find active work going on. The very fact that the tissue is dead and discolored is evidence that the organism has sapped it of all nutriment and is through with it. The work of destruction goes on

outside this line of dead tissue, and extends a variable distance, from only three or four, to twelve or fifteen inches. So in cutting be sure and make the cut sufficiently low to remove all the infested tissue. If the tree becomes very badly affected before receiving attention, it is best to grub it out and burn the entire tree.

VARIETAL DIFFERENCES.

There appear to be no varieties that are entirely free from attack, but, according to reports, there are wide differences in susceptibility and in resisting power. The testimony concerning pears, gathered from many sources, indicates that Anjou, Angouleme and Seckel resist attack better than do Bartlett, Clapp or Flemish Beauty, and when attacked the disease progresses less rapidly in the first three, than it does in the last three.

Among apples, the varieties of crabs seem everywhere more susceptible than do standard apples, but even here occasional exceptions are met with. A case illustrating this came under my notice at Eaton.

A three-acre garden was surrounded by a row of crabs, Martha and Whitney alternating. The Whitney trees were all either dead or dying of the disease, while not a Martha had been attacked. The difference between the two varieties was here so marked as to suggest security from attack on the part of the Martha, but in other localities the variety has succumbed. Reports concerning the standard varieties of apples vary greatly from different localities. Varieties apparently immune in one locality are badly attacked in another, and I am inclined to the belief that the differences in behavior toward the disease, with both pears and standard apples, are due more to varying local conditions than to varietal differences.

The crabs are so universally attacked that it seems undesirable to plant them at all. In choosing varieties of standard pears and apples, be governed by the best local experience, and by the fruit list as recommended by the Board of Horticulture. Then by rational treatment bring about those conditions of growth that make the trees least liable to attack. If trees are attacked follow the course outlined in the preceeding pages, and by persistence eradicate the disease, or at least hold it in check.

Of remedial preparations offered for sale I have nothing to say. Having stated the cause of the disease, and outlined its manner of work, I leave the probability of cure to the judgment of the intelligent reader.

MECHANICAL INJURIES

TO WHICH

FRUIT TREES ARE SUBJECT.

The disease we have attempted to discuss is only one of the many sources of injury to which our fruit plants are liable. Aside from the numerous insect pests which are demanding constant attention, we have a long list of parasitic fungi, and certain other mechanical injuries whith result from peculiarities of climate. Some of these deserve brief mention here.

The mechanical injuries referred to are commonly spoken of as "frost-crack" and "sun-scald," and both are referred to a combined action of sun and frost. Most of the cases of so-called sun-scald that have come under my observation have proved to be cases of blight upon the trunk or large branches. They are characterized by dark, discolored areas of dead bark, commonly circular or elliptical, but sometimes irregular in form, and most frequently, though not always on the side exposed to the sun. The dead bark as it dries shrinks and adheres closely to the wood.

Frost cracks occur upon the exposed side of the trunk, extending longitudinally. They are produced in winter and early spring under the influence of extreme low temperatures, and may, when growth starts close and entirely heal. The liability of trees to injury of this character depends mainly upon the amount of water contained within the tissues. Trees that grow late, and enter the winter with wood not thoroughly ripened, and hence containing more water, are more susceptible to injury than those that are enabled to ripen and harden the wood. Even well ripened wood contains normally about 40 per cent. of water. Trunks of apple trees cut on the fifteenth day of January 1897 when

last weighed, on the eighth of January 1898 showed a loss of water by air drying of 39.36 per cent. and branches from the same trees lost in the same time 42.24 per cent. The weights are not yet quite constant, but the figures may be taken as an approximate showing of the moisture contained in normal tissues in midwinter. But this moisture is not in the easily freezable liquid form; it is distributed as a constituent of cell wall, and in the viscid or solid cell contents, and can only be withdrawn and crystalized under the prolonged action of extreme cold. Suppose a tree thus normally constituted to be subjected, during the winter or early spring, to a period of warm bright weather. The influence of the sun's rays penetrates the tissues, the cell contents become less viscid, water taken in by the roots still further liquifies these cell contents, there is movement within the cells and they become turgid with fluid sap. A sudden change marked by temperatures below zero occurs. There is a gradual shrinking of the tissues until the point of actual freezing, or crystalization is reached, and then comes that familiar and seemingly resistless expansion. If the sap-gorged tissues escaped rupture during the process of shrinking they are sure to yield to the expansive force accompanying congelation.

This form of injury is usually worse on plums, cherries, and peaches, than upon apples and pears. The cracks are less likely to heal; they more often increase in size, and the exudation of gum is followed by rot which leads to the death of the tree.

With all trees this trouble can be in large measure prevented by providing some protection against the sun. This protection is most needed when the trees are young; as they attain size they in a measure protect each other. Various devices have been used, but we find wrapping with burlap the cheapest and most effective. Burlap that has been used for baling was purchased at dry goods stores at two cents per pound. One pound supplies twelve strips four inches wide and three feet long, and one strip is sufficient for a reasonably low-headed tree three to five years in orchard. The burlap being cut, and strings of proper length at hand, one man will wrap the trees at the rate of 60 an hour. The cost is thus nominal and the protection afforded ample.

More serious than the the frost crack is that mechanical injury which is characterized by a separation of the bark from the wood. It has thus far been reported upon apple

trees only, and most of the cases of which I have knowledge occurred in the southern portion of the state.

The separation between wood and bark in those cases examined occured near the ground, and was not noticeably confined to any particular side.

In most cases the bark appeared discolored over a portion of the separated area, and more or less ruptured as if from lateral tension in drying. Between the discolored portion and the limits of the affected areas the separated bark often appeared perfectly healthy, and in some cases new growth was protruding into the space between bark and wood. A few cases were found that gave no visible sign of injury beyond a slight change from the normal color of the bark. There was nothing to indicate the size of the affected areas; the bark was smooth and apparently healthy, but when struck emitted the hollow sound that proved a sure test of the extent of the injury. In cases of this kind it would seem that considerable time might elapse between the working of the cause and the discovery of its effect, and I apprehend that the first evidence of injury would be seen in a generally unhealthy appearance of the foliage of the tree. Of course, if the trunk was affected to the extent of girdling it, the tree would soon die. If the affected area was confined to one side the tree might endure for some years, but with vitality diminished in proportion to the extent of the injury.

Where small areas only are affected the tree may by the intrusion of newly formed tissue, completely cover the denuded wood and thus effect a cure. From the location of this trouble beneath the bark, and from the tardy appearance of any evidence of injury, it is clear that a practical demonstration of the cause would be difficult if not impossible. I am not aware that any actual demonstration of the working of the cause has ever been made. Since the trouble became known its origin has been assigned to the action of frost, but there was no tangible basis for the assumption until the matter was taken up and critically studied by Professor Burrill of Illinois. The results of his observations and the theoretical deductions from them were presented in a paper before the American Association for the Advancement of Science at the Ann Arbor meeting in 1885. After explaining frost cracks, and the phenomena attending the crystalization of liquids by frost, he says—"The second form of injury -especially prevalent in apple trees—is believed to be due to the *growth* of ice crystals studding in a close or dense layer, the surface upon which

they form. Such miniature forests of crystals can be found in green plants even after slight freezing, as well as in ripened wood in severely low temperatures." The process of crystal growth is further explained as follows: "In the trunks of trees the crystalizations begin in any part where there is proportionally most pure water. The very process of solidification causes, by the law of equal diffusion, a movement of water from adjoining parts, toward the point from which the first liquid (as such) is removed. Hence the ice crystals first formed constantly grow, attracting as it were the water from neighboring parts of the tissue. This growth of the crystals, associated as they occur in close layers, pushes asunder the normally connected tissues." The theory here given being based upon careful observations, and being in perfect accord with physical laws has been accepted as the true explanation of the trouble under discussion. It will be noted that the operation of the theory depends upon the presence of fluid sap, and that the greater the water content of the tree the more liable it is to injury. It follows that the same conditions that protect against other frost injuries will protect against this. Fruit growers should therefore, use every endeavor to thoroughly ripen the wood of the trees before winter sets in and thus reduce the liability to injury from frost to the minimum.

FUNGOUS DISEASES.

Leaf Blight or Rust of the strawberry. This is a cosmopolitan disease due to the parasitic fungus known as Sphærella fragariæ. While our climatic conditions are in general unfavorable for the development of this disease, we do occasionally have periods during which it does injury. Moisture is necessary for the germination of the spores, and the fungus can spread to an injurious extent only during moist and warm weather. The month of June, 1895, was marked by prevailing high temperature and frequent showers, and during that time the disease did considerable damage to strawberry beds about Fort Collins. This past season the disease started under somewhat similar conditions toward the latter part of May, but showers becoming less frequent it did no serious damage.

All growers are familiar with the purple or red spots which mark the presence of this disease. These spots enlarge and become of a brown color; finally, by the growth of the spores beneath, the cuticle is ruptured and they then appear white at the center with a brownish ring outside. Affected leaves soon turn brown throughout and die.

This loss of foliage saps the vitality of the plant, and if

the attack comes early in the season it prevents the development of a full crop of fruit. If the attack comes after the fruit has been harvested the plants are weakened so that the crop for the next year will amount to nothing, or at least be shortened, depending upon the severity of the attack. As the mycelial threads of the fungus are within the leaf tissues it is apparent that preventive, rather than curative measures must be resorted to. The fungus survives the winter within the leaf, both by spores and by its mycelium. It follows that the destruction of infested leaves in the fall is important as a means of holding the disease in check. The practice of mowing the old leaves after the fruit has been removed and then burning is not to be recommended because it sometimes results in injury. It is better to rake the leaves off the bed for burning and then by cultivation and the application of ferlilizer induce a vigorous new growth preparatory to fruiting the next season.

The simplest and most effective way of controlling the disease is, however, by spraying with any of the standard fungicides adapted for application to foliage. The following have been successfully used. Hyposulphite of soda, one pound to ten gallons of water, applied every ten days. Modified "Eau celeste" made as follows—Dissolve one pound copper sulphate in two gallons of water; in another vessel dissolve one pound of Sodium carbonate; mix these two solutions and when chemical action has ceased add one and one-half pints of ammonia. Dilute to 25 gallons. Ammoniacal copper carbonate made by dissolving three ounces copper carbonate in one quart of ammonia, and diluting to 25 gallons. Three or four applications of the copper solutions are usually sufficient.

ORANGE RUST OF BLACKBERRIES AND RASPBERRIES.

This disease has been reported from Arvada and other places near Denver, and has been present here in Fort Collins for the past three years. It has not been particularly destructive, but the damage done is sufficient to warrent a word of caution. Eastern growers have in many places suffered severely from the disease, and it would be well to profit by their experience and use every effort to exterminate it. The cause of this disease is a true fungus (Cæoma nitens) which has been known under various names since 1820.

Its presence has been reported from nearly every state east of the mountains: it is common in Canada, and is also known in Europe. Apparently it is confined in its work to

plants of the one genus-Rubus, but has been observed on nearly every species of the genus. It works on wild as well as on cultivated plants, and appears to prefer some species to others. As between the dewberry and the blackberry it works most upon the dewberry: and between the black and red raspberries the blacks are more susceptible to attack. The disease also shows choice of varieties: thus the Kittatinny and the Erie blackberries seem much more susceptible to attack than do Snyder and Wilson.

The presence of the disease can be detected quite early in the spring in the tufted slender shoots which are produced, and in the glandular appearance given to some of the new leaves by an early and little understood spore form which the fungus produces. Later, about the first of June the Æcidium or cluster cup spore formation may be looked for. The cluster cups first appear as small raised spots covering the under surface of the leaves: soon the skin is ruptured, the cups containing the spore masses protrude, and then we have that characteristic appearance which suggested the name orange rust.

This, the fruiting stage of the fungus is conspicuous, and cannot fail to attract attention, but it is not all there is to the plant.

The vegetative portion consisting of very minute threads which ramify through the plant, and which must develope before spore formation can take place is not apparent to the naked eye: it gives no sign of its presence except by inducing the tufted growth of slender shoots.

It will readily be seen that this vegetative portion of the fungus is beyond the reach of any curative applications that might be made. It is secure within the tissues of the plant, and since it has been proved that the threads extend into the roots and are perennial, we are led to the conclusion that our only course is to completely destroy the infested plants Spraying has been recommended as a protection against the spreading of the fungus by the spores, but spraying will be unnecessary if the plants are carefully watched and the infested ones removed before the dissemination of spores begins.

ANTHRACNOSE OF THE RASPBERRY AND BLACKBERRY.

In 1896 canes of black-cap raspberry infested with this disease were sent us from near Denver. From the fact that nothing has been heard of the presence of the disease since, we regard this as an isolated case introduced, in all probability, on plants from some eastern nursery. The

dryness of our climate is not favorable to the development of this disease and we apprehend no serious trouble from it; but as it is liable to appear at any time on introduced stock, it may be well to dwell briefly upon its characteristics. The cause of the disease is a fungus (Glœosporium venetum) and Professor Burrill of Illinois is credited with publishing the first account of it in 1882 under the name Raspberry Cane Rust. The disease appears to be confined to the blackberry and black-cap raspberry. As with the orange rust the vegetative threads of the fungus ramify within the plant and are perennial. The first evidence of the presence of the fungus is seen in small, purplish, circular or elliptical spot on the canes near the ground. As the canes grow the fungus ascends and the spots appear at intervals even to the tips of the canes. The spores are formed about the centers of these spots and as they push outward the bark is ruptured and curled back. The spots then appear grayish white with a purplish border. Often several spots may coalesce forming irregular patches. While the principal work of the fungus is on the canes, it is not wholly confined there, but may appear on the petioles and veins of the leaves. The nature of this fungus suggests the cutting out and burning of all canes seen to be affected. As a preventive measure it is recommended to spray, as soon as the canes are uncovered in the spring, with a solution of sulphate of iron, two pounds to five gallons of water, to be followed later, if the disease appears, by an application of the Bordeaux mixture.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 42.

SUGAR BEETS IN COLORADO IN 1897.

Approved by the Station Council,

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

FEBRUARY, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station publications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,

Fort Collins, Colorado.

EXPRESS, FORT COLLINS

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FORT COLLINS, COLORADO.

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SUGAR BEETS IN COLORADO IN 1897.

W. W. COOKE AND WM. P. HEADDEN.

During the past few years the interest in the growth of sugar beets has largely increased. The Colorado Experiment Station has for many years been encouraging their growth in Colorado, but the work of 1897 was conducted on a larger scale than any previous year. The United States Department of Agriculture at Washington gave the Station five hundred pounds of beet seed for conducting the trials, and the Station also received two hundred pounds from A. Keilholz, Quedlinburg, Germany, through his United States agent, F. G. Zimpel, New York City. The government seed was the Kleinwanzlebener variety, imported by the Oxnard Beet Sugar Co. and sent to us from Norfolk, Nebraska. The seed from A. Keilholz was the Imperial White variety.

With this large amount of seed on hand, it was determined to extend the experiments over all the agricultural sections of Colorado. Notices were inserted in the newspapers of the State, to the effect that the station would send the seed to those that applied for it, and who would promise to take good care of the crop and report results in the fall. Applications were received from and seed sent to six hun-

dred and eleven persons, representing forty-seven counties.

One pound of seed was sent to each person, accompanied with a copy of a bulletin giving full directions for the planting and care of the crop. How the directions were carried out will be noted in another place in this bulletin.

The seed was sent out in April and early May. About the middle of June a circular was sent to each one who had received seed, asking for information as to the planting of the crop. A copy of this circular is given later in this bulletin.

Of the six hundred circulars sent out, less than two hundred and fifty were ever returned, showing that not half of those who applied for the seed really desired to ascertain whether or not they could grow beets fit for sugar purposes.

When the time came in the fall for taking samples of the crop for analysis, it was deemed best that some at least of these samples should be taken by a representative of the Station so as to know better than it could be told on any blank, the exact circumstances under which the crop was grown and its condition at the time the samples were taken. With this object in view, the agriculturist of the Station visited about forty farms situated east of the range, secured samples of the beets, and made full notes of the conditions.

When the work of the season was planned it had been hoped that the new chemical laboratory of the college would be completed in season, so that most of the beets could be analyzed in Fort Collins. Owing to unavoidable delays, this building has not even yet been completed, and in the crowded condition of the old laboratory still in use, it was found impossible to make many more analyses than were required by the tests of beets grown on the college farm.

In this predicament, the Secretary of Agriculture at Washington came to the rescue, and through his kindness, nearly all the samples taken of beets grown outside of Fort Collins, were analyzed at Washington.

It was soon found that to get samples enough to fairly represent the different parts of the state would require more time than any representative of the Station had to spare, and therefore the first of October a circular was sent out asking those who had grown sugar beets to take samples and forward them direct to Washington.

At the same time there was sent to them from Washington, blanks for describing the samples and shipping tags, so that the beets could be sent by mail free of postage.

Below are given copies of the two papers sent from Washington.

UNITED STATES DEPARTMENT OF AGRICULTURE.

WASHINGTON, D. C., *August 15, 1897.*

Directions for Taking Samples of Sugar Beets for Analysis.

Prepared by H. W. WILEY, Chief of Division of Chemistry.

When the beets appear to be mature (September 15 to November 15, according to latitude and time of planting) and before any second growth can take place, select an average row or rows, and gather every plant along a distance which should vary as follows, according to the width between the rows:

From rows		16	inches apart,	length		75	feet.
"	"	18	"	"	"	66	"
"	"	20	"	"	"	59	"
"	"	22	"	"	"	54 and four-fifths feet.	
"	"	24	"	"	"	50	"
"	"	28	"	"	"	42 and nine-tenths	"

The beets growing in the row, of the length above mentioned, are counted. The tops are removed, leaving about an inch of the stems, the beets carefully washed free from all dirt and wiped with a towel. Where the row is not long enough to meet the conditions, take enough from the adjacent row or rows to make up the required length. Rows of average excellence must be selected; avoid the best or poorest. Throw the beets promiscuously in a pile and divide the pile into two parts. This subdivision, of one-half each time, is continued until there are about ten beets in a pile. From these ten select two of medium size. Be careful not to select the largest or smallest.

From all the rest of the beets, save these two, the necks are removed with a sharp knife at the point indicated by the dotted line in the figure. The beets, including the two saved as a sample, are then weighed.

The number of beets harvested multiplied by 435.6 will give the total number per acre. The total weight of beets harvested multiplied by 435.6 will give the yield per acre.

Wrap the two sample beets carefully in soft paper, and write your name legibly thereon. The beets must be perfectly dry. Fill out blank describing beets, enclose in the envelope, and sew up in bag with beets. Sew the beets up in a cotton bag, attach the inclosed shipping tag thereto, and send by mail.

No beets will be analyzed which are not sampled as described above and properly identified..

Miscellaneous analyses of samples without accurate description are of no value.

Blanks are sent to each one for two sets of samples. From two to four weeks should elapse between the times of sending the two sets of samples.

If additional analyses are desired other blanks will be sent on application, but not more than four analyses can be made for any one person, except in special cases.

A model, showing how blanks should be filled out, is inclosed.

U. S. DEPARTMENT OF AGRICULTURE.

DESCRIPTION OF SAMPLE OF SUGAR BEETS.

Prepared by H. W. Wiley, Chief of Division of Chemistry.

Variety ....

Date planted ....

Date thinned ....

Date harvested ....

Character of soil ....

....

....

....

Character of cultivation (dates, implements, etc.) ....

....

....

....

....

Length of row harvested (feet) ....

Width between rows (inches) ....

Number of beets harvested ....

Total weight of beets harvested, less necks and tops, (pounds) ....

....

Weather for each month ....

....

....

....

....

State ....

Post-office ....

Date ....

Name ....

Note—Samples of beets will not be analyzed unless accompanied with this blank filled out as indicated in model B.

The first samples were taken September 13, when the crop showed no signs of ripening. Several samples were taken during the next week and quite a number on September 24 and 25. In every case the beets were found in full growth and far from ripe. Analyses of these samples showed them to be low in both sugar and purity.

Of thirty-three samples taken, only two were found that were above twelve per cent in sugar and also above eighty per cent in purity, this being the ordinary standard adopted by sugar factories for merchantable beets. Four other samples showed below eighty per cent purity, but enough above twelve per cent sugar to make them of value for factory use.

In the following table the results of these early samples are omitted as the crops evidently, were too green for harvesting. Many of these fields were again sampled later in the season and the results of the second set of samples are given in the table.

Several statements need to be made in regard to these tables. They are intended to represent ripe crops. Besides the samples just mentioned, quite a number of other analyses were omitted when it was know that the crops were not ripe when the samples were taken. All analyses of ripe crops are entered, even though the analyses show that the crops were unfit for factory use.

These tables represent the character of the beets that were received for analysis, at the time they were received. It does not necessarily follow that they represent a fair average of the field from which they were taken or that when received at the labratory they were in the same condition as when pulled in the field. A great many of the samples were not taken by employes of the Station and we have to trust to the judgment of the person sending the sample, that it correctly represents the field. The greatest single chance for error is in the drying out of the sample between the time it is pulled and the time of analysis. In some cases this would increase the analysis, while in others, through fermentation of the beets, the results would be lowered. The instructions say clearly to wrap the beets carefully in paper in order to keep from drying out, and where the instructions have been followed the results are closely correct. But some samples have been received in bad shape. Indeed the analyses of some fifteen or more samples have been omitted from the tables because the samples themselves showed that they had dried out to such an extent that their

analyses did not represent the beets as they stood in the field.

For the purpose of this bulletin, the State has been divided into five sections.

1. The valley of the South Platte and its tributaries.

2. The Divide, south of Denver where crops are raised without irrigation.

3. The valley of the Arkansas.

4. The valley of the Grand.

5. The San Luis Valley.

Under each section the samples are given in the order of time that the beets were dug, since it is found that this factor has been more powerful than any other in determining the quality of the beets.

All the seed used was Kleinwanzlebener except the samples double starred which are Vilmorin and those starred which are Imperial White.

PLATTE VALLEY.

No	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
1	C M C Woolman.....	Sterling	Sept 18	11	14.5		16
2	" "	Sterling	" 18	9	12.5	76.3	16
3	F C Marks............	Sterling	" 18	13	13.2	86.0	9
4	T B Robinson........	Fort Morgan	" 29	20	13.3	82.8	*9
5	S M Scott............	Fort Morgan	" 29	13	16.1	81.3	8
6	J A Davis............	Berthoud	Oct 2	21	13.9	81.6	29
7	C A Caykendall.......	Loveland	" 3	22	14.4	78.7	30
8	L A Dwight...........	Boulder	" 4	24	13	77	29
9	Arthur Ling...........	Greeley	" 5	40	13.4	87	40
10	J W Bacon ** Upland	Longmont	" 15	63	14.6	81.4	21
11	" " **.......	"	" 15	15	15.4		21
12	" " ** Lowland	"	" 15	26	12.5	76.2	22
13	" " **.......	"	" 15	19	14	82.1	22
14	D M Lambert.........	Bellevue	" 20	14	15.5	76.4	
15	Fred Greve...........	Crook	" 15	18	16.5		15
16	Chas Johnson.........	Atwood	" 20	14	15.2	82.4	11
17	R S True..............	Highl'nd Lake	" 20	27	16.2	85.9	
18	W S Simpson.........	Fort Morgan	" 28	19	16.1		20
19	W W Remington......	"	" 16	29	13.7	80.4	25
20	J A Davis.............	Berthoud	" 28	28	16.7	84.5	35
21	F M Wright..........	"	" 30	20	14.1	77.5	10
22	C Cornelius...........	Lafayette	Nov 1	28	14.3	77.7	30
23	C Reed................	Orchard	" 1	13	16.1	82.8	47
24	S M Scott.............	Fort Morgan	" 1	15	15.6	80.4	12
25	H C Hatch.	Sterling	" 1	43	12.7	75.6	23
26	L A Dwight	Boulder	" 4	16	18	84.3	31
27	J J Thomas *	Lafayette	" 23	29	20	86.4	36
28	" " *	"	" 7	73	14.4	80	
29	W M Post	Fort Collins	" 9	25	13.3	74.4	18
30	T R Baldwin..........	Bijou Basin	Oct 15	20	12.7	73.1	
31	Alfred Johnson.......	Atwood	Nov 12	19	15.3	83.3	
32	J A Davis.............	Berthoud	" 7		15.5	86	
33	E K Smith............	Fort Lupton	" 8	19	14.5	80	
34	Fritz Neimeyer.......	Evans	" 6	74	14.2	81.2	
35	" "	"	" 6	53	12.6	78.3	
36	" "	"	" 6	41	11.5	81.8	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
1	May 22		Thick	June 15	July 3	July 1	Black heavy loam.
2		Same as	No. 1				
3	June 10		Good		July 10		First crop on new breaking bottom land.
4	May 5		Thick	May 25	June 29	May 14	Rich garden soil manured '97
5	May 15		Uneven		July 15	June 25	Sandy loam.
6	April 20	10	Thick	June 2	June 6	June 24	Sandy, with clay subsoil; broke ground May 28.
7	May 27	4	"				Rich bottom, irrigated 3 times.
8	May 7		"		June 15		Clay soil, manured in 1897.
9	May 10	4	"	July 15	July 10	Sept 5	Black bottom land, irrigated only once.
10	May 20	3	Good				Heavy loam,
11	"	Same as	No. 10				
12	"	3	Good				On bank of river, considerable alkali.
13		Same as	No. 12				
14	May 23	4	Thin	June 25			Light mountain soil.
15	May 10		Thin				Sandy loam; subirrigation.
16	May 24	16	Thick		June 26	June 12	First crop on new land; plowed three inches deep.
17	June 1		very poor			July 2	Land irrigated before plowing
18	May 15	20	Thick	May 1	June 1	June 15	Medium heavy soil; irrigated three days before planting.
19	May 22	10	Medium		Never	Late	Irrigated by flooding, no after cultivation.
20	April 20	Same as	No. 6				Still growing October 28; manured 1896.
21	April 27	6	Poor		June 10		Rich clay soil; seed irrigated up; manured 1896.
22	May 1	15	Fair		June 10	June 15	Sandy with clay subsoil; manured 1897.
23	May 10	20	Thick				Sandy soil; seed irrigated up, Broken 1896.
24		Same as	No. 5				
25	May 15	8	Thick	June 10	Never		Alkali ground; seed irrigated up; manured 1897.
26		Same as	No. 8				
27	May 8		Thick				Manured 1897.
28		Same as	No. 27				
29	May 5	15	Medium	June 15	June 28	June 21	Mountain soil; manured 1897.
30	June 1	4	Medium			Never	Very sandy loam.
31	May 24	11	Fair	June 13	July 1		New land; seed irrigated up.
32		Same as	No. 6				
33	April 20		Thin	May 20	Aug 15	Never	Watered by seepage from reservoir; sandy loam.
34	May 26			June 20			Sandy loam; manured 1897.
35		Same as	No. 34				
36		Same as	No. 34				

DIVIDE, SOUTH OF DENVER, WITHOUT IRRIGATION.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Puritty.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
37	C H Clark	Eastonville	Sept 12	6	14.7		
38	F Holkowiez	Elizabeth	Oct 1	14	13.1	71.5	22
39	Alex Brazelton.......	Elbert	" 2	18	13.4	77.9	9
40	Geo H Stein..........	Fondis			13.6	80.3	
41	J D Steves............	Parker	" 5	12	12.8	69.5	
42	W B Quein............	Hilltop	" 9	22	15.7	85.5	17
43	Alice H Kent..........	Kiowa		26	11.6	87.7	
44	" "	"		28	16.9	83.9	
45	S H Rasmussen *	"	" 11	19	13.3	76.0	9
46	" " *	"	" 11	10	15.0		9
47	H C Hansen *	"	" 12	8	17.0		10
48	" " *	"	" 12	12	17.1		10
49	Mrs John Underhill *	Fondis	" 15	9	18.7		
50	D C Dormer *	Castle Rock	" 15	18	18.7	78.4	
51	Chas Shedd...........	Otis	" 20	11	13.8	78.4	
52	Wm Duffy	Fondis	" 21	26	15.3	76.2	
53	G H Ellicott..........	Ellicott	" 30	38	14.2	80.1	
54	Miss H S Jones......	Elizabeth		12	16.7	75.7	
55	D C Dormer *	Castle Rock	Nov 14	27	18.6	81.2	

ARKANSAS VALLEY.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Puritty.	Weight of crop per acre.
56	Sidney Flinn..........	Caddoa	Oct 3	18	14.7		
57	" "	"	" 3	20	19.4		
58	M D Parmenter	Lamar	" 6		15.0	78.5	
59	C G Anderson........	Eldred	" 7	14	12.4	75.6	
60	J W Jameson *	Howard	" 10	11	13.8	80.1	12
61	B F Wyckoff..........	Rocky Ford	" 15	35	13.5	79.3	
62	C G Anderson........	Eldred	" 23	19	16.0	84.8	13
63	B F Wyckoff......,....	Rocky Ford	" 28	24	12.7	78.7	40
64	W F Crowley.........	" "	Nov 5	34	14.4	84.3	31
65	C K McHarg..........	Pueblo	" 13	16	20.2	85.9	24
66	M D Parmenter	Lamar	" 15	19	17.1	83.9	40
67	" "	"	" 15	26	12.4	77.8	
68	" "	"	" 15	34	12	72.8	
69	B F Rockafellow.....	Canon City	" 15	34	17.0		27

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
37	May 20	20	Thick			Never	Black sandy soil.
38	May 17	20	Thick	June 20	June 20	"	Second crop from sod; daily rains Sept 16 to Oct 1
39	May 1	12	"	July 15	July 15	"	Sandy bottom land; manured 1897.
40	April 28	6	"	May 20	June 25	"	Sandy loam; 2d year from sod.
41						"	
42	May 2	8	Thin	May 26	May 26	"	Black sandy loam; second crop from sod.
43	Apr 29	2	Thin	May 27	June 1	"	Black sandy loam; manured 1897.
44		Same as	No. 43				
45	May 15	6	Thick	June 25	June 25	"	Firm sandy loam.
46		Same as	No. 45			"	
47	May 15	5	Thin	June 20	June 29	"	Black sandy loam.
48		Same as	No. 47			"	
49	June 1	8	Thick	June 18		"	Black sandy loam.
50	May 20	4				"	High prairie soil with a little adobe.
51	May 20	12	Thin	July 5	July 18	"	Sand with clay: manured 1897.
52		2		Never		"	Sandy loam; broken in 1896.
53	May 15	8				"	Light sandy loam.
54	June 1		Thick		July 10	"	Sandy loam; manured 1896.
55		Same as	No. 50			"	
56	May 25		Fair	June 3		June 26	New ground, rather heavy; seed irrigated up.
57		Same as	No. 56				From a dryer part of the field.
58	June 1		Thin	June 10	June 28	June 14	Sandy soil; maured 1897.
59	Mch 25	10		April 13	April 15	April 20	Black sandy loam.
60	June 3	10	Poor	June 18	July 4	June 15	Light sandy soil.
61	April 30	20	Good	May 20	May 20	May 10	Clay soil, with some grit.
62		Same as	No. 59				
63		Same as	No. 61				
64	May 19		Good	June 10	Never	June 28	Inclined to clay soil with some alkali.
65	May 10	9	Medium	June 15	June 26	June 15	Sandy soil, second year from breaking.
66		Same as	No. 58				No late irrigation.
67		Same as	No. 58				Medium late irrigation.
68			No. 58				Irrigated late in the season.
69	May 8	24	Thick	June 7	June 7	June 2	Adobe soil; manured 1897 seed irrigated up.

No.	Name.	Address	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
70	Ira D Hale...........	Rocky Ford	Nov 20	35	13.4	77.3	17
71	" "	"	" 20	16	17.3		
72	J R Traxler..........	Lamar	" 1	10	16.5	75.5	25
73	" "	"	" 1	12	15.9		25
74	" "	"	" 10	15	14.7	85.4	
75	" "	"	" 10	16	14 4	81.0	

GRAND VALLEY.

No.	Name.	Address	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
76	Levi Ward...........	Debeque	Sept 15	39	11.9	78.1	20
77	D G Edgerton *	Carbondale	" 18	10	14.4	82.5	18
78	H L Edgerton *	"	" 18	9	15.4		14
79	G S Osburn...........	Satank	Oct 1	11	14.1	78.0	
80	W C Smith	Cardiff	" 1	6	17.3	86.0	
81	Thos King	Glenw'd Spr'gs	" 1	19	13.3	83.0	
82	Mrs M H Lafever	Eagalite	" 1	22	17.0	88.1	
83	C R Thompson	Glenw'd Spr'gs	" 2	9	13.8	77.0	
84	C B Sewell...........	Carbondale	" 3	20	12.2	81.0	
85	C B Sewell.......	"	" 3	13	18.5		
86	J L Thomas	"	" 11	13	16.1	85.9	14
87	D G Edgerton.... ...	"	" 12	21	12.5	83.0	16
88	C H Harris	Catherin	" 12	13	17.4	85.0	
89	E Stauffacher.........	"	" 12	16	15.6	81.2	
90	Wm Gardner	Satank	" 12	10	19.0	86.9	
91	E E Westhafer........	"		28	18.9	84.9	
92	C M Rulis n..........	Parachute	" 12	11	15.2	79.9	42
93	Levi Ward	Debeque	" 12	18	17.6	86.0	15
94	Geo Siever...........	Glenw'd Spr'gs	" 15	18	15.0	80.1	
95	C D Fuller...........	"	" 15	17	14.9	83.0	
96	J L Brown	"	" 15	12	16.8	85.4	
97	B M White	"		10	15.2		
98	W V Hall	Peachblow	" 15	14	14.5	81.7	15
99	Cyrus King	Antlers	" 30	20	14 6	83.0	
100	J E Thomas	"	Nov 15		14.0	74.0	

SAN LUIS VALLEY.

No.	Name.	Address	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
101	C M Thomas..........	Monte Vista	Oct 1	11	13.4	77.5	14
102	M B Colt..............	Alamosa	Sept 28	17	11.5	80.5	23
103	Mrs H C Hefner......	Mosca		12	15.9	86.9	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
70	May 10		Thick	June 5	June 1	May 25	Sandy loam.
71		Same as	No. 70				
72	May 25		Good	June 20	June 25	May 28	Hard soil.
73	May 1		Thick	May 25	June 10	May 28	Sandy loam.
74		Same as	No. 73				
75		Same as	No. 72				
76	May 15		Thick	June 10	June 10	June 10	Sandy loam, manured 1897; seed irrigated up.
77	May 15	8	Poor	June 24	June 24	May 25	Black sandy loam; manured 1897; broke ground June 1.
78	May 1	16	Thick	May 30	June 15	June 1	Clay loam, heavily manured 1896 and 1897.
79	May 10			June 6			Red sandy loam.
80	May 5	70	Medium	June 10	June 15	May 25	Sandy loam.
81	May 20			June 15			Sandy loam.
82	May 3	4	Thick	June 15	June 19	June 15	Sandy soil, manured 1897; daily rains Sept. 15-30.
83	May 16				June 7		Sandy loam.
84	May 16	32	Thick	June 10	July 7	June 1	Sandy loam, heavily manured 1897.
85		Same as	No. 84				
86	May 2				June 15	July 1	Sandy loam; heavily manured 1897.
87		Same as	No. 77				
88	May 1		Thick	May 25	June 20		Yellow sandy loam; seed irrigated up.
89	May 26		Good		July 10	July 10	Gypsum soil.
90	May 20				June 25		Red sandy loam.
91	May 28		Thick	June 22	July 10	June 20	Very sandy soil.
92	June 6			June 20	Never	June 21	Heavy sandy bottom land.
93		Same as	No. 76				
94	May 14				June 27		
95	May 1	13	Thick		May 25		Red sandy loam.
96							
97							
98	May 20	20	Good				Sandy loam; seed irrigated up injured by hail.
99	May 15	5	Thin	June 28	July 2	June 6	Alluvial soil, seed irrigated up; manured 1897.
100	June 20						Sandy loam.
101	May 12				June 15	Sub	Rich sandy loam; heavy rains before digging.
102							Alkali soil.
103	May 25		Thick	June 14	July 15		Sandy loam; seed irrigated up.

No.	Name.	Address.	Date when sample was dug.	Average weight of the beets analyzed.	Sugar.	Purity.	Weight of crop per acre.
				Ounces.	Per cent.	Per cent.	Tons.
104	David Albright.......	Poncha Spr'gs	Oct 4	29	13.6	79.5	16
105	W A Lockett..........	Saguache	" 7	10	16.5		11
106	S L Pierce............	Montevista	" 10	7	17.3		14
107	Chas Milne............	La Jara	" 12	38	13.4	78.7	33
108	M B Colt..............	Alamosa	" 13	9	15.7	78.9	
109	N G Shaw.............	"	" 22	14	17.9	85.9	31
110	David Albright.......	Poncha Spr'gs	" 25	16	17.4		19
111	Chas Milne...........	La Jara	" 28	31	16.4	84.3	33
112	M B Colt	Alamosa	Nov 3	25	16.1	83.6	23
113	G J Stafford *	Montevista	" 11	15	12.4	76.5	10
114	Mrs H C Hefner......	Mosca		13	16.3	84.6	
115	W G Bradshaw	Alamosa	Oct 25	39	14.2	74.2	9
116	" "	"	" 25	38	11.9	70.6	
117	Wm Cross	"		34	13.4	74.5	
118	C M Thomas	Montevista	" 26	33	15.0	81.9	
119	A K Deitrich	"	" 10	17	17.6	84.1	18

OTHER PARTS OF THE STATE.

120	Geo H Hammond....	Hotchkiss	Nov 15	23	15.5	76.7	20
121	J L Ellis **	Craig		10	19.0	81.2	
122	" " **	"		11	18.6		
123	Chas A Barnes **	Delta	" 10	16	18.6	84.3	
124	Chas R Peter..........	Holyoke	Oct 4	61	11.4	75.4	
125	" "	"	" 4	37	14.7	70.0	

No.	Date of planting.	Pounds of seed per acre.	Stand.	Date of first cultivation.	Date of thinning.	Date of first irrigation.	Remarks.
104	May 9	13	Good				Rather sandy; heavily manured; seed irrigated up.
105	May 15	10	Fair			June 16	Sandy loam.
106	May 20		Thick	June 25	June 10		Sandy loam; manured 1896
107	May 8		Thick	June 1	June 4		Sandy loam; manured 1897; seed irrigated up.
108							Adobe soil.
109	May 20	2	Uneven	July 2	July 2		Black sandy loam; seed irrigated up.
110		Same as	No. 104				
111		Same as	No. 107				
112		Same as	No. 108				
113	May 5	8	Thick	June 1	June 15		Sandy soil, manured last three years; seed irrigated up.
114		Same as	No. 103				
115	May 24	16	Thick	June 24	July 1	July 3	Dark yellow soil and gravel.
116		Same as	No. 115				
117	June 2	4	Uneven	July 1	July 1		Clay: manured last two years; seed irrigated up.
118		Same as	No. 101				
119	May 10	15	Thick	July 1	June 15		Sandy soil; fifth year continuously in beet.
120							Sandy loam.
121							
122							
123	May 25		Good	June 20	July 1	June 1	Sandy soil; new breaking.
124	May 1	6	Thin	June 1	June 20	Never	Sandy loam; manured 1897.
125		Same as	No. 124				

TIME OF RIPENING.

From the standpoint of the manufacturer, the date at which the beets become sufficiently ripe for use, is one of the most important parts of the problem. A beet sugar factory costs several hundred thousand dollars. At the most, it can work but about a third of the year and must be idle capital the rest of the time. In the climate of Colorado, it would not be safe to calculate on running later than the last of January. If the factory should start the first of October, it could have a run of a hundred and twenty days. Every day before the first of October that it could run would increase the amount of beets that could be handled and the profit on the whole investment. As the net profits of a well conducted factory are more than five hundred dollars per day, every additional day is of great importance.

The results given in the foregoing table throw much light on the date at which sugar beets in Colorado may be expected to ripen.

In the valley of the South Platte, north and northeast of Denver, the samples taken in September showed conclusively that the beets were not yet ripe. But a great change takes place in the last days of September and in the first week of October. The average of the samples taken between September 25 and October 10 is 14.1 per cent sugar and 80.7 per cent purity. This is an excellent grade of beets for factory use. Had a factory been in operation in the valley of the Platte during the season of 1897, it could have started up about September 25 with beets running over thirteen per cent in sugar and about eighty per cent in purity. It is not meant by this that all the beets raised in the valley had reached that average at that date, but that on the three to four thousand acres of beets that would be grown for a factory, there would have been enough beets ready by September 25 to have kept the factory running until other beets ripened.

This is a very important matter and cannot be too carefully considered. To get the crop ripened is the principal aim of the beet grower since it is in the last stages of growth that the beet forms most of its sugar, and it is only when the beet becomes ripe that the juices become pure enough for profitable manufacture.

Several factors come in to influence the ripening of the sugar beet. The most important is this that *the beets shall keep growing all the time from the sprouting of the seed until harvest*. All of the directions given for the planting and cultivation of the crop have this object in view;

because if this is attained, both the quantity and quality of the crop are almost necessarily correct.

If the beets receive no set back, they make a large growth, ripen early, and at the end of the growing season, get rid of much of the impurities in the juice, and store up in the root a large amount of pure sugar. If, however, for any reason the growth of the beet is checked, even for a few days, the ripening is delayed for a much longer period; if the check is severe the beets will never ripen, but start a second growth that will keep on growing until killed by the frost.

Provided the beet grower has given the proper care, the actual date of ripening will then depend on several conditions, some of which are beyond his control. If the ground is very rich it will tend to increase the size of the beets and retard the time of ripening. But an important fact is to be remembered in this connection. No matter how rich the ground is, if the beets are properly cared for, they will eventually ripen and be all the better, both in quantity and quality for the abundance of plant food that has been at their disposal. But the richer the ground is the easier it is to start a second growth and produce an enormous weight of crop of a poor quality.

An abundance of moisture in the soil retards the ripening of the beet, so that if the fall is unusually rainy the crop will be late in maturing. In Colorado it is true in general that the crop will not ripen until the vigor of the growth has been checked by frost.

The fall of 1897 in northeastern Colorado was exceptional, in that the frost held off two or three weeks later than usual and more than the average amount of rain fell. If, then, under these adverse natural conditions, a factory could have started September 25, it is fair to presume that under average conditions it could have begun operations several days earlier.

In this connection it is important to note the fact that on September 18, there were found at Sterling, two fields of beets that were fully ripe, weighing ten and sixteen tons of beets respectively per acre, and the beets of a good quality for factory use. This shows that with extra good care these beets had been brought thus early to merchantable condition in spite of the unfavorable weather. What these two men did, others similarly situated, could have done by equal care. Both of these crops were on medium to light soil. It is probable that no one on a heavy clay soil could have brought the beets to ripeness by this early date.

But one other factor remains to be noticed in regard to the ripening of the crop. All of the beets in northeastern Colorado were grown from seed imported from Germany. The experiments conducted at Lehi, Utah, make it probable that by using seed grown in the United States at five thousand feet altitude the ripening of the crop is hastened from a week to ten days.

In view of all the foregoing statements, we have a right to conclude that whenever a factory is actually built in northeastern Colorado, it will find beets ready for manufacture soon after the middle of September.

After what has been said of the ripening of beets in northeastern Colorado, there need be but little said concerning the other portions of the state. The same principles govern the ripening everywhere. On the Divide, south of Denver, where beets are grown without irrigation, the crops matured somewhat later than in the valley of the Platte, with irrigation. The content of sugar reached thirteen per cent by the first of October, but the purity was then too low for manufacturing purposes. By the middle of the month the beets were all right for the factory.

The Arkansas Valley is one hundred and fifty miles south of that of the Platte and as a natural result frosts hold off late and the beets are late in ripening. Had a factory started up October 15, it could probably have found beets enough to keep it running, but the bulk of the crop was hardly in marketable condition before the first of November. On the other hand, the winters here are so open and mild that there would be little trouble in a factory running all winter or until the crop was all handled.

The analyses from the valley of the Grand show that the crops were easily ready for the factory by the first of October and probably several days earlier. The bulk of the crop was ready at least a week or ten days earlier than that of the valley of the Platte. The climate of the valley of the Grand is a little warmer than that of the Platte and hence it would be supposed that the crop would ripen later rather than earlier. The cause of this result must be due either to better care, or to different seed, and is probably due to both these causes. The farmers in this valley have been experimenting in the raising of sugar beets for several years, and many of them have made a careful study of the subject. Hence their fields were better cared for, the quality of the crop was better, and it ripened earlier.

The remaining section of Colorado is the San Luis valley. The analyses from this section are so mixed that it is

difficult to judge when the crop in general was ripe. There were only two samples dug before October 15 that could be profitably manufactured. These two, however, show such a very high grade as to seem to indicate that the lateness in ripening of the other crops was due to lack of care or the presence of too much alkali in the soil.

INFLUENCE OF RIPENING.

The process that goes on in the ripening of the beet is both an increase of pure sugar and a decrease of the impurities. This raises both the per cent of sugar and the per cent of purity. By the purity of the beet is meant the relation of the sugar to the whole amount of material in the beet that is not water. Suppose 100 pounds of the juice of some beets contain 80 pounds of water and 20 pounds of solids; and of that 20 pounds of solids 16 pounds are sugar; then it is said that the beet has sixteen-twentieths or eighty per cent of purity.

The following table gives ten cases where samples were taken from the same field at different times in the fall.

EARLY AND LATE SAMPLES.

Name.	Place.	Date when sample was dug.	Average weight of the beets.	First sample.		Second sample.	
				Sugar.	Purity.	Sugar.	Purity.
			Grams.	Per cent.	Per cent.	Per cent.	Per cent.
S M Scott............	Fort Morgan	Sept 24 Nov 1	430 425	11.5	71.7	15.6	80.4
T B Robinson	"	Sept 24 " 29	310 567	11.9	78.3	13.3	82.8
J A Davis	Berthoud	Oct 2 " 28	595 794	13.9	81.6	16.7	84.5
L A Dwight	Boulder	Oct 4 Nov 4	680 454	13.0	77.0	18.0	84.3
C G Anderson	Eldred	Oct 7 " 23	397 538	12.4	75.6	16.0	84.8
Levi Ward...........	Debeque	Sept 15 Oct 12	1389 510	11.9	78.1	17.6	86.0
Mrs H C Hefner	Mosca		340 368	15.9	86.9	16.3	84.6
David Albright	Poucha Spr'gs	Oct 4 " 25	824 454	13.6	79.5	17.4	
M B Colt............	Alamosa	Oct 13 Nov 3	240 709	15.7	78.9	16.1	83.6
Chas Milne,..........	La Jara	Oct 12 " 28	1361 879	13.4	78.7	16.4	84.3
		Averages.	617 570	13.3	78.6	16.3	83.9

It is not claimed that this is an exact scientific comparison between early and late samples, for in some cases the samples were taken from different parts of the field and in others they were quite different in size. The figures, however, serve to illustrate forcibly the general truth that in the late days of its growth, the beet accumulates sugar rapidly and becomes of much purer quality.

In the ripening of sugar beets, there is not only an increase of sugar and consequently a relative decrease of the impurities, but there is also an absolute decrease of impurities. This is shown in the next to the last column of the following table, which is based on the results of about two hundred analyses of the Colorado beet crop of 1897.

Beets ranging in per cent. of Sugar from	Water.	Total Solids.	Insoluble Fiber.	Sugar.	Soluble Impurities.	Per cent of Purity.
8 to 11	81.0	19.0	5.0	9.9	4.1	70.2
11 to 12	79.7	20.3	"	11.6	3.7	76.0
12 to 13	78.8	21.2	"	12.5	3.7	77.0
13 to 14	77.9	22.1	"	13.5	3.6	78.8
14 to 15	77.1	22.9	"	14.4	3.5	80.9
15 to 16	76.1	23.8	"	15.4	3.4	82.0
16 to 17	75.4	24.6	"	16.5	3.1	84.1
17 to 20	73.8	26.2	"	18.2	3.0	85.8

QUANTITY OF CROP.

There seems almost no limit to the amount of sugar beets that can be grown on an acre of ground in Colorado. The soil of the State is wonderfully rich and the large amount of sunshine stimulates the growth of the crop wonderfully. The yields given, represent in most cases, estimates based on the digging and weighing of rather small areas, and would need to be decreased considerably to represent whole fields. But even if shrunk one-half, which is far more than necessary, the yields are above those of any state that now has a beet sugar factory in operation. The writer visited a great many beet fields during the fall of 1897 and was everywhere struck with the rank growth and general healthy, vigorous look of the crop. It is a common belief that it is not difficult to raise a large crop, but that a large crop always means one poor in sugar and purity. Such does not seem to be the case in Colorado. Some of the largest yields have been accompanied by a high percentage of sugar and extra good purity.

It would be difficult to make an estimate of the average yield per acre of sugar beets in Colorado during 1897. The extreme would be from half a ton to nearly forty tons per acre. The beets on the College farm were a very poor stand owing to bad weather at the time of planting. The different fields varied from half a stand to hardly a quarter of a full stand. The rows were two feet apart and the entire crops, taking all the ground planted, were from eight to twelve tons to the acre.

The average of fifteen fields at Sterling and Fort Morgan is 17.4 tons of beets per acre gross weight, equivalent to about 15 tons of trimmed beets ready for the factory.

The weights of the crops on the Divide are of course much less than these figures. The valleys of the Arkansas and Grand have given about the same yields as that of the Platte, while the San Luis valley comes forward with some surprisingly large yields. Chas. Milne, at LaJara, reports about thirty tons to the acre, testing 16.4 per cent sugar and 84.3 per cent purity; while N. G. Shaw, at Alamosa, harvested over fifteen tons of beets from a measured half acre of ground and the beets tested 17.0 per cent sugar and 85.9 per cent purity. One of the heaviest yields reported is that of J. A. Davis, at Berthoud, who raised at the rate of 35 tons to the acre testing 16.7 per cent sugar and 84.5 per cent purity.

Probably the most profitable sugar beets raised in Colorado the past season were those grown by J. W. Bacon, seven miles east of Longmont. When his field was prepared for wheat, he left out about an acre and planted this later to sugar beets, giving the land but one more harrowing in addition to its preparation for wheat. Only three pounds of seed were used per acre, in drills thirty-two inches apart, sown with the ordinary wheat drill. The plants were not thinned, were irrigated but twice, when the water was turned on the wheat, and received only such cultivation as would be given an ordinary field of corn. The crop from the acre was twenty-one tons of beets, which tested 15.0 per cent sugar and 81.4 per cent purity.

QUALITY OF CROP.

The question of the quality of the crop has been referred to several times in speaking of its quantity. In making any estimate of the quality of the beets raised in Colorado in 1897, it is of course unfair to use any of the analyses made of crops that were known to be unripe. By the middle of October it is fair to presume that the sugar content had

about reached its full limit. There were fifty-one samples reported after that date ranging from 10.5 per cent sugar with 72.4 per cent purity, to 20.9 per cent sugar and 85.3 per cent purity, with an average of 15.5 per cent sugar, and 81.6 per cent purity. What has been done by these growers on their first attempt ought certainly to be equaled on a large scale for factory use when they are better aquainted with the best methods.

One point needs to be specially mentioned. The large crops average the highest in quality. The nine fields, of which we have analyses from the ripe crops, reporting over twenty tons of beets per acre with an average of twenty-seven tons, test 16.0 per cent sugar and 82.6 per cent purity. Such fields would return to the grower over a hundred dollars per acre and give to the factory nearly three hundred dollars worth of sugar per acre.

COMPARISON OF 1897 WITH PREVIOUS YEARS.

Sugar beets have been raised on the Station farm and in various parts of Colorado for the past nine years. The records of the analyses include many high and many low results. The records from outside the Station are not accompanied with the dates when the samples were dug, or any statement of the ripeness of the crop, so it is not possible to tell whether the low analyses are due to the poor quality of the crop or to the early date at which the samples were taken.

The different varieties of beets raised at the Station in 1897 agree in quality quite closely with the samples of previous years, when the samples were taken at the same date or stage of growth. Judged by this standard, the year 1897 was the same or a little poorer than previous years.

In all the states that have factories, and raise beets on a large scale, the universal report is that the year 1897 has been exceptionally poor; indeed about the worst known since the factories started. Since this report comes from Nebraska, Utah and New Mexico, east, west and south of Colorado, it is probable that in this state it was not any better than an average year.

METHODS USED BY BEET GROWERS.

There are certain principles of beet growing that have been learned by experience and by experiments in this country and in Europe, that are considered as essential to the production of the best beets. It is undoubtedly true that these principles are correct, and that the beet growers of

Colorado will eventually accept and practice them, and thereby increase the quantity of their crops and improve their quality. But the point to be considered here is this: most of the tests in 1897 were made by persons who had never grown beets before; they violated all of the proper methods and still produced large crops of good beets. What stronger proof could be obtained that the soil and climate of Colorado are especially adapted to the sugar beet?

One of these rules is that sugar beets should never be planted on new ground. Such soil it is claimed is so full of soluble salts as to make the beet too impure for factory use. Chas. Johnson, at Atwood, reports that his beets were planted on newly broken land and they tested 15.2 per cent sugar and 82.4 per cent purity. Sidney Flinn, at Caddoa, under similar conditions on rather clay ground, which in Colorado would ordinarily be very rich in soluble salts, produced beets that contained 19.4 per cent sugar. Though the purity was not determined, it could scarcely have been less than 83 per cent.

The only other two persons who reported beets on new ground, had samples taken in September before the beets were ripe, but even in these two cases the beets tested better than the average of their neighbor's beets on old ground.

There were six cases reported where the beets were raised on ground that had been broken a year before and had raised one crop before the beets. These give uniformly fine beets and average 17.3 per cent sugar and 82.6 per cent purity.

All rules for sugar beet culture say to subsoil if possible, but if not, to plow very deep, and better if plowed in the fall. No subsoiling was done by any of the farmers; about a third of them plowed in the fall and but few plowed more than eight inches deep. It is probable that subsoiling in Colorado under irrigation is labor lost. Deep plowing is an advantage with the clay soils, but in the alluvial soils of the river bottoms which will be the land most used for beet culture, the roots go deep into the soil, whether the plow is run deep or shallow.

Another point was noticed in all the fields visited. The beets grew with the entire root under ground. This makes a little more labor in digging, but it lessens the amount of the top of the beet that has to be cut off with the leaves and increases the amount of sugar in the upper part of the root. It is probable that this fact goes far toward explaining the higher average quality of Colorado beets over those of the neighboring states. Just why the beets should grow so in Colorado is not yet evident, unless it is due to the furrow

irrigation which deposits the water below the soil rather than on its surface and tempts the beet to go deep for it. The writer noticed particularly at Grand Island, Nebraska, the past season, that nearly one-third of the weight of the beet was above ground, making a loss in the amount that was trimmed off and a poor quality in the upper inch that was left on the beet.

All writers on sugar beet culture are agreed that beets should not be planted on ground that has recently been manured with stable manure, because its tendency is to make a large beet that is late in ripening and is low in sugar and purity. Sixteen persons report that they manured their beet ground before planting it. The crops were large as was to be expected, and it was also true that unless the samples were dug late in the season the quality is low. The stable manure seems to have made them late in ripening, but on the ripe crops, the quality is good with three exceptions. As these three are almost the only ripe crops that are poor it seems a fair conclusion that the result is due, in part at least, to the stable manure. Taking the results as a whole they indicate much more gain than loss from the addition of stable manure.

One of the special advantages claimed for Colorado in the matter of beet raising is, that under irrigation, water can be kept away from the crop during the latter part of the season, allowing it to ripen and reach the full amount of sugar and purity. This is undoubtedly correct, but one queer sample shows that even this rule may have exceptions. Mrs. M. H. Lafever of Eagalite, sent a sample that was dug the first of October, after two weeks in which it had rained every day. Yet the beets tested 17 per cent sugar and 88.1 per cent purity.

The effect of alkali on sugar beets is still an open question, as is also the result of growing beets on seepage ground. As throwing some light on the latter question, two examples may be quoted. At Greeley, A. L. Camp Jr., planted beets on some strongly alkali seepage ground and they tested 6.8 per cent sugar and 46 per cent purity. Mr. Camp makes the statement that these beets were the first things he had found that were able to grow in the presence of so much alkali. E. K. Smith at Fort Lupton, grew beets on land kept moist by the seepage from a reservoir and his beets tested 14.5 per cent sugar and 80 per cent purity. Both raised large crops without irrigation, but in the first case the beets showed a large amount of second growth indicating that there had been a time when they had suffered from

lack of water, while the other beets were some of the finest seen during the season. They were finely shaped, thoroughly ripe, with nothing on the crown but the first growth of leaves. In other words the seepage from the reservoir had been constant through the season and just enough to give the beets all the water they wanted all the time.

STAND.

The number of beets to the acre determines in large measure the weight of the crop and its character. In general it can be stated that the more crowded the beets, the smaller they will be, but richer in sugar and of a higher purity; the farther apart, the larger and poorer they will be.

There should be some medium ground that will produce the largest amount of sugar beets per acre. This is approximately when there is one beet for each square foot of ground. If the rows are two feet apart, this would leave six inches between the plants. With eighteen inch rows, the distance between the beets would be increased to nine inches.

The hardest part of beet raising is to get a full stand all over the field. More than half of those who raised beets in 1897 report the stand as thin or poor. Two pounds of beet seed contain enough seed to make a full stand on an acre of ground, but to get this stand in practice it is necessary to sow a much larger amount. The idea is to sow a good deal more than is needed and then thin out the plants to the required distance. It is customary in the vicinity of factories to sow fifteen to twenty pounds of seed to the acre. The records show that different beet raisers in Colorado sowed varying amounts from two pounds to two hundred and seventy-five pounds to the acre. The average was nine pounds per acre, but more than half of the persons used less than eight pounds per acre or less than half the proper amount.

The poor growth of the seed is due to lack of moisture in the ground, too deep planting, and poorly prepared ground. East of the range, in Colorado, the first, due to the dry winters, will always be the greatest objection. It is possible to overcome this in two ways; by irrigating the field before the seed is planted, or by irrigating after the seed has been sown. The first is better if it can be done, but it is very likely that the second will come to be used as the regular method in growing beets for factory use.

Quite a number of persons tried this method in 1897. Fifteen persons report the resulting stand as follows: one,

poor; two, fair; one, uneven; two, good; one, thick in places; eight, thick. In other words eight out fifteen obtained a thick stand by irrigating up the beets.

This is about twice as large a proportion as those who obtained a thick stand by depending on rain or the original moisture in the ground.

Of two persons who irrigated ten days after the seed was planted, both report poor stands. Of two persons who irrigated before the seed was planted one reports a good stand and the other poor.

No relation can be traced between the stand and the analysis of the crop, for there is no record to show whether the beets analyzed grew by themselves or were taken from thick places in the field.

RECAPITULATION.

The results of the season of 1897 may be summarized in a few words.

Good sugar beets can be raised anywhere in Colorado that is adapted to any kind of farming. Large crops of good beets can be raised in any portions of these districts that are supplied with water for irrigation. The season opens early enough and the winters are mild enough so that a factory could have a run of at least one huudred and twenty days.

The average quality of the ripe crops of Colorado in 1897 was 15.5 per cent sugar and 81.6 per cent purity. The average quantity of beets per acre was not far from sixteen tons.

FACTORY CONDITIONS IN COLORADO.

Those who contemplate putting their money into a beet sugar factory will desire to receive answers to several questions in addition to those already presented.

It has been shown that Colorado has the soil and climate for the production of high grade beets. A natural question follows as to whether the people of the State are enough interested in the matter to raise the beets if a factory was built. The answer to this must be in the affirmative. This has been tested on several occasions and there would be no trouble in getting the necessary acreage pledged at several places in either the Platte, Arkansas, Grand or San Luis valleys.

A home market exists in Colorado for all the sugar that would be produced by three large factories, thus saving freight on the finished article. Each of the above mentioned regions is near to enormous deposits of coal, affording an abundance of cheap fuel. The deposits of limestone are

adjacent to the farming districts and much of the lime itself is almost chemically pure. Pure water for factory use can be easily obtained.

Indeed it can be said in all truthfulness that no place where a factory is now in operation presents advantages equal to those posessed by any one of half a dozen localities in Colorado.

INFLUENCE OF DRYING ON BEETS.

In the raising of sugar beets for a factory, it is customary to dig beets during the early part of the season, as fast only as the factory can use them. At the end of the season, in countries where there is danger of the ground freezing, all of the crop is harvested and either brought to the factory and stored in bins or piles or else the surplus of beets are piled up in the field where grown and covered with a thin layer of dirt to prevent their freezing.

It becomes a question of great importance to both beet grower and beet manufacturer as to what changes if any will occur in the beet during the weeks that elapse between digging and slicing.

Some investigations along this line were made at the station in 1897. Samples of beets were weighed and placed where the conditions would be much the same as those in the field, other samples remained in the cellar of the laboratory, others in the laboratory itself, while still others were buried in dirt.

The two ideas were to find out how fast beets dry out under these conditions and whether there is any loss of sugar when the beet dries. The first is important to the grower, because if he sells his beets by the ton, all the drying out reduces his tonnage. The second is equally important to the manufacturer, because having bought the beets and paid for the sugar in them at the time of delivery, he wants to know whether the sugar will keep until he is ready for its extraction.

A few of the results obtained will be given here in anticipation of the fuller figures to be published in a technical bulletin on the chemistry of the growth and handling of sugar beets.

On October 29th, a lot of beets were taken from a field on the College farm and divided into three equal lots; one was taken to the laboratory at once and kept in a cool, dark place; the second lot was left lying on the ground in the field exposed to the sun as would happen in ordinary practice. The next day this lot was gathered and analyzed,

together with the first lot. The third lot was piled up in the field, covered with a few inches of dirt and allowed to remain for five weeks before analysis.

The results are as follows.

	Per cent sugar.	Per cent purity.
Kept one day in a cool place,..	14.0	82
Left one day in the open field,.	14.9	79
Covered five weeks with dirt,..	14.7	84

The results show that the beets dried considerably during the one day exposed to the sun, but that in this case and also where covered with dirt, the loss was merely one of water, the sugar in the beet remaining without fermentation.

This was with ripe beets taken from a dry soil. No judgment can be drawn from this as to what would happen with unripe beets.

On October 6th, two lots of beets were taken; one from a field fairly ripe and the other still green and growing. Half the beets in each lot were analyzed at once; the other half were weighed, wrapped tightly in paper and put on the ground in the cellar of the laboratory. Both lots were weighed each day for sixteen days, to note the loss in weight and then each was analyzed.

In each case the beets lost one-twentieth of their weight in the first twenty-four hours or at the rate of a hundred pounds for each ton of beets. In five days each lot lost a little more than one-fifth of its weight. In sixteen days each lot lost thirty-eight pounds for every hundred pounds of original weight.

The more nearly ripe beets tested, when put in the cellar 9.8 per cent sugar; at the end of sixteen days they had dried out until they tested 15.9 per cent sugar. When the weights are taken into consideration it is found that of the 9.8 per cent of sugar in the original beets 9.55 per cent was still present, showing that the sugar had not fermented in the drying out and that the loss was merely one of water.

The green beets tested 9.3 per cent sugar when taken from the field and 12.6 per cent sugar after drying sixteen days. Making the same calculation, shows that of the original 9.3 per cent sugar, only 7.7 remained, indicating a fermentation and a loss of one-sixth of the sugar.

On January 3, 1898, some beets were dug that had been covered with straw for two months. They had started a slight second growth, but not enough to injure them for factory use. After analyzing enough of these beets to get their average composition, the remainder were brought to the laboratory and left for one day exposed to the air. They

lost just one-twentieth of their weight the same as in the fall. They were then covered with three thicknesses of sacking, but continued to dry out and in five days had lost nearly one-fifth of their weight. At the end of fifteen days they had lost just the same as the beets did in the fall in sixteen days. The beets tested originally 14.4 per cent sugar; fifteen days afterward they tested 21.6 per cent sugar. Calculations of weight show that of the original 14.4 per cent sugar, 13.4 per cent remained, or a loss by fermentation of about one-fourteenth of the sugar.

EFFECT OF FREEZING ON BEETS.

When the beet fields on the college farm were harvested, several small patches were left and allowed to freeze. After the tops had frozen and thawed several times the whole was covered with a thick layer of straw. Samples of these beets were analyzed at various times up to the middle of January 1898. From near the edge of the straw some beets were dug that had been partially frozen.

The first beet analyzed had been only slightly frozen. It was cut into thirds by weight and each third analyzed.

	Per cent. sugar.	Per cent. purity.
Upper third	12.9	78.7
Middle third	12.0	91.1
Bottom third	12.0	81.4

The second beet had been decidedly frozen.

	Per cent. sugar.	Per cent. purity.
Upper third, all froxen	10.9	73.2
Middle third, partly frozen	11.2	70.3
Bottom third, not frozen	14.3	88.3

Here the effect of the freezing seems to have been to drive the sugar into the lower part of the beet.

One of the patches of beets covered by straw tested the first of November when covered, 12.3 per cent. sugar and 77 per cent. purity. On January 3, the same patch tested 13 per cent. sugar and 86 per cent. purity. This was a patch of large beets and and to the eye they had increased in weight during their two months under the straw.

COLORADO SOILS.

The relation between the growth of the sugar beet and the character of the soil in which it grows has been studied very carefully in Europe. Almost nothing of this kind has been done in the United States. The results of the work in 1897 seem to indicate that it is not safe to apply the rules

formulated in Europe with beets dependent on rainfall, to our Colorado conditions, where the beets are grown with irrigation. This opens up a wide field for experiment and research. No one station in any one season can hope to compass the problem. The following soil analyses made by Mr. Chas. Ryan are presented as a contribution to the subject. They should be studied in connection with the analyses of the beets grown in the several sections.

Much more of this work will need to be done before any generalizations can be drawn.

PLATTE VALLEY.

	No. 3 Weld County	No. 53 Weld County	No. 32 Logan County	No. 36 Morgan County
Water		1.48	1.57	1.33
Soluble and insoluble silica	85.92	86.12	86.38	86.98
Potash	0.38	0.54	0.70	0.56
Soda	0.30	0.16	0.46	0.86
Lime	0.97	1.38	1.36	0.19
Magnesia	0.40	0.42	0.18	0.05
Iron Sesquioxide	3.01	2.43	1.76	0.99
Alumina	3.96	3.52	6.19	5.53
Phosphoric acid	0.31	0.11	0.03	0.04
Sulphuric acid	0.26	1.13	0.05	0.39
Carbonic acid	0.28			0.06
Volatile and organic matter *	4.42	2.52	2.02	2.67
Chlorine	0.05	0.05	0.05	0.05
Total	100.26	99.86	100.12	99.60
* Containing nitrogen	0.13	0.07	0.11	0.16

DIVIDE SOUTH OF DENVER.

	No. 14 Douglas County	No. 16 Elbert County
Water	1.42	1.34
Soluble and insoluble silica	82.12	87.04
Potash	0.37	0.46
Soda	0.51	0.93
Lime	0.24	0.12
Magnesia	0.28	0.42
Iron Sesquioxide	2.54	1.54
Alumina	8.34	3.83
Phosphoric acid	0.03	0.01
Sulphuric acid	0.20	1.19
Carbonic acid	0.02	0.48
Volatile and organic matter *	3.10	2.66
Chlorine	0.07	0.04
Total	99.24	100.06
* Containing nitrogen	0.13	0.12

ARKANSAS VALLEY.

	No. 38 Otero County	No. 27 Las Animas County	No. 42 Prowers County
Water	1.55	1.66	2.65
Soluble and insoluble silica	83.26	83.04	78.00
Potash	0.91	0.25	1.69
Soda	0.52	0.11	0.54
Lime	1.76	1.55	1.44
Magnesia	1.06	0.11	0.79
Iron sesquioxide	2.38	2.93	2.78
Alumina	4.45	4.70	5.94
Phosphoric acid	0.14	0.90	0.09
Sulphuric acid	0.50	0.45	0.60
Carbonic	1.15	1.01	5.79
Volatile and organic matter *	3.25	3.70	
Chlorine	0.09	0.04	0.03
Total	100.12	100.45	100.34
* Containing nitrogen	0.12	0.06	0.13

GRAND AND GUNNISON VALLEYS.

	No. 19 Gar-o field C	No. 21. Gunni-son Co
Water	2.82	2.30
Soluble and insoluble silica	77.88	72.51
Potash	1.38	0.75
Soda	0.63	0.86
Lime	0.71	2.05
Magnesia		0.58
Iron sesquioxide	2.07	2.86
Alumina	8.27	10.24
Phosphoric acid	0.14	0.01
Sulphuric acid	0.44	1.46
Carbonic acid	0.21	
Volatile and organic matter *	5.32	6.21
Chlorine	0.06	0.05
Total	99.93	99.98
* Containing nitrogen	0.16	0.13

SAN LUIS VALLEY.

	No. 5. Rio Grande County.	No 44. Rio Grande County.	No. 9. Conejos County.	No. 10. Costilla County.	No. 40. Saguache County.
Water		1.48	3.50	2.17	3.97
Soluble and insoluble silica	80.75	80.67	70.24	79.77	75.05
Potash	0.53	0.90	0.68	0.26	0.11
Soda	0.94	0.77	1.98	2.31	0.44
Lime	1.62	1.55	1.46	1.65	2.10
Magnesia	1.40	0.95	0.44	0.14	0.67
Iron sesquioxide	1.84	5.40	2.94	1.42	3.60
Alumina	7.90	5.09	5.07	8.03	5.33
Phosphoric acid	0.21	0.09	0.06	0.07	0.11
Sulphuric acid	0.22	0.67	0.02	0.39	1.10
Carbonic acid	0.70		0.38	0.01	
Volatile and organic matter *	3.63	3.00	13.10	4.57	7.41
Chlorine		0.09	0.03	0.06	0.09
Total	99.78	100.66	99.90	100.85	100.18
* Containing nitrogen	0.11	0.09	0.23	0.18	0.24

THE CAMPAIGN OF 1898.

It is evident that the more interest there can be aroused in Colorado in the culture of the sugar beet, the more likelihood there is of the erection of factories.

The Experiment Station has taken an active interest in the matter for several years and proposes to devote more time and energy than ever before to the campaign of 1898.

Seed will be distributed, free of charge, to those who desire to make tests of raising sugar beets. The seed will be sent out early in April, to those who desire it. Applications should be sent in at an early date. Enough seed will be sent to each applicant to plant fifteen rows, fifty feet long or their equivalent. This small area is selected because it is desired to know the best that Colorado can do, and that is most likely to be ascertained when the amount planted is small enough so that it can be put on the best land and given the best of care and attention.

Those who receive seed will be expected to keep full records concerning the crop.

About the middle of July the following circular will be sent out. It is suggested that those who receive seed make their records directly on this bulletin, of which they will have a copy, and from which they can copy these records on to the blank when it is received.

COLORADO AGRICULTURAL COLLEGE.

SUGAR BEET CIRCULAR NO. 1.

FACTS CONCERNING THE PLANTING OF THE CROP.

Date planted . . . .

Character of soil . . . .

. . . .

Much or little alkali in soil . . . .

Previous cropping and handling . . . .

. . . .

. . . .

When last manured . . . .

Date plowed . . . .

Plowed how deep . . . .

Other preparation given . . . .

Seed planted with what implement........................

Seed planted how deep........................

Width between rows........................

Was all the seed sent used?........................

How much land was planted?........................

Date beets began to show above ground........................

Date of each cultivation........................

How cultivated........................

Date of thinning........................

Distance between plants after thinning........................

Is the stand thick or thin?........................

Date of each irrigation........................

(Signed) Name........................

Postoffice........................

NOTE.—Fill out the blank the first of August and send by mail to

THE STATE AGRICULTURAL COLLEGE,
Fort Collins, Colorado.

The analyses of the beets will be made at Fort Collins. Instructions for taking and sending samples will be sent out next fall. No beets will be analyzed unless accompanied by the full history of the planting, cultivation and harvesting of the crop.

It is desired that two samples of the crops be taken, one early in October and the other about the first of November. No samples will be analyzed after the middle of November.

INSTRUCTIONS FOR THE GROWING OF SUGAR BEETS.

Select the best land on the farm. A rather heavy loam produces the best crops. Avoid light, sandy soils, poorly drained soils, heavy clay soils and alkali soils. Do not plant on newly broken ground unless it can be plowed very deep. Never plant beets on alfalfa sod. Beets do best after corn or potatoes. The freer the land is from weeds the easier and cheaper will the crop be raised. On land that has been manured just before plowing, it is difficult to get a good stand of beets, but if the choice has to lie between poor land and rich land recently manured, always take the rich land.

Plow at least eight inches deep; harrow thoroughly and smooth the ground before planting. Fall plowing is best, to be again plowed in the spring before planting. Whether fall plowed or not, the spring plowing should be done as short a time as possible before planting. If possible the seed should be planted the same day that the ground is plowed so as to have the benefit of all the moisture in the ground for germinating the seed. If a large acreage is to be planted, it should be handled in sections, plowing only what can be planted at once. On a large acreage it is advisable to plant the ground in three sections from five to seven days apart, so that the thinning will come at different times and economize labor.

Sugar beets can be planted from early in April until the last of May. In general they are planted about the same time as corn. They should always be sown under such conditions of warmth and moisture that the seed will germinate at once and the young plants show above ground within ten to fourteen days after planting.

Beet seed should be sown in drills from 16 to 24 inches apart; most beet seeders are made for 18 inch drills. The seed can be sown by hand, by the common garden drill, by a wheat drill closing up some of the holes, or regular beet drills can be used that are made for the purpose and sow four rows at a time. Sow the seed from half an inch to an inch and a half deep. Sow as near the surface as it is possible for the seed to get enough moisture to germinate. The earlier in the season the seed is sown, the less depth it should be planted. If the ground is very dry, sow near the surface and then irrigate up the seed by making a small furrow between every other row and running a small stream of water until the ground has wet sideways to both rows. Remember that getting a good stand is the hardest part of sugar beet raising.

Sow plenty of seed ; never less than fifteen pounds to the acre and from that to twenty pounds.

The thinning should be most carefully and promptly done, as on it depends in large measure the weight and quality of the crop. There is but one time to do this work, and that is while the plants are very young—just as soon as the third or fourth leaf becomes well defined and the root is nothing but a mere thread. If delayed the plant receives a set back from which it can scarcely recover. Just before thinning, work the ground between the rows with a hoe or

with a horse cultivator made to work the same number of rows at a time as were sown by the seeder. Next follow with a sharp hoe four to six inches wide, cutting across the row and dividing it into bunches six to nine inches apart. These bunches are thinned by hand to a single plant. The plants should be from six inches apart in a twenty-four inch drill up to nine inches apart in an eighteen inch drill.

After the thinning go through the field once more with the hoe and be sure that every weed is killed. The rest of the cultivation needed during the season is only such ordinary cultivation as would be given to a crop of corn.

Irrigate the beets only when they show the actual need of it. Delay the first irrigation as long as possible unless it is necessary when the seed is planted to produce germination, in which case the water should be turned on within two days after the seed is in the ground.

A slight wilting during the day does not necessarily mean need of water, but when they wilt and do not revive as soon as the sun sets or the weather is cloudy, they should be watered. After the first watering they will usually dry out quickly and need subsequent irrigations every ten to fourteen days. Few beets can be raised in Colorado without irrigation, the number of irrigations varying from two to five according to the ground and the season. Beets will seldom need irrigation after the middle of August and usually not after the last of July. Unless the ground is very compact it will be sufficient to run the water in every other row. At the next irrigation use the rows omitted the previous time. Cultivate after every irrigation. Never flood sugar beets if it can possibly be avoided. Be careful in cultivation and in furrowing not to throw any dirt on to the crown of the plant. Keep the irrigation water as much as possible away from actual contact with the plant.

Wait until the beets are ripe before harvesting ; ripeness can be told by the wilting and dying of the outer leaves, by slicing a beet and noting that the cut surface remains white for a half hour or more, but best of all by a chemical test for the sugar it contains. At a factory this latter method is the one always employed.

On a small scale the beets can be dug out, plowed out or pulled. On the large scale they are always loosened by a beet puller made specially for the purpose. They are then lifted out by hand, thrown into piles and topped by hand with a corn knife or a heavy chopping knife.

GROWING SUGAR BEETS FOR FACTORIES.

BY GEORGE H. WEST.

DR. ALSTON ELLIS, DIRECTOR,
UNITED STATES EXPERIMENT STATION.
Fort Collins Colo.

DEAR SIR:—The following investigation of beet growing and the conditions at and around the beet sugar factories in Nebraska, Utah and New Mexico, was made for the purpose of learning if it pays the farmers to grow beets for the sugar factories of four dollars per ton, and how they are grown to produce good beets at a minimum cost.

The writer has tried to present the absolute facts, whether favorable or not, leaving the reader to draw his own conclusions.

The visits to Utah and New Mexico were by authority of the Denver Chamber of Commerce, thus making it possible to investigate the important features of beet raising by irrigation.

The trip to Norfolk, Nebraska, was made early in October, 1897, and to Grand Island; Nebraska, the latter part of that month. Lehi, Utah, was visited late in December, i897, and the Pecos Valley, New Nexico, late in January, 1898.

Yours Respectfully,
GEORGE H. WEST,
Greeley, Colo., Feb. 18, 1898.

THE NORFOLK, NEBRASKA, BEET SUGAR FACTORY.

The Norfolk Beet Sugar Co. has operated this factory since 1891. It is owned by the Oxnards, no stock being held by residents of Norfolk. The factory is located about two miles north of the city, and obtains its water from the north fork of Elkhorn creek. It has a nominal capacity of about 250 tons of beets per day. The machinery is said to be mostly of German make. The Steffen process is used to obtain the sugar from the molasses.

The price paid for beets is for delivery at the factory, and the following deductions are made for freight charges on the U. P. and F. E. & M. V. railroads: 25 miles or under, 30 cents per ton; over 25 miles and under 45 miles, 50 cents per ton; over 45 and under 100 miles, 80 cents per ton. C., St. P., M. & O. R. R., 30 miles or under, 50 cents per

ton; over 30 and not over 40 miles, 60 cents per ton; over 40 and not over 50 miles, 80 cents per ton; switching charges $2 per car added to these rates on latter line. All beets in 1897 were grown inside the 45 mile limit.

The factory employs 200 hands, on two shifts, of twelve hours each. A few boys are employed. Common factory wages are from $1.50 to $2 per day. Skilled labor from $60 per month upward. The employes are paid every two weeks, in cash. There are no company stores. All business is done through the local banks.

The factory uses about 12,000 gallons of crude oil (Eastern) per day, for fuel in generating steam for power and other factory uses. This is two tank cars of 6,000 gallons each. Two men do all the work in the boiler house, where fourteen were required up to 1895, when coal was used. Cost of oil was not given, but the manager says that bituminous coal, within fifty miles of a factory, would be cheaper than the fuel used at either Norfolk or Grand Island. About fifty tons (three cars) of lime rock are used per day. This comes from Nemeha county, Neb., near Plattsmouth, some 100 miles distant. Cost not given. About a car load of sulphur is used each season.

The same forms of contracts are made with farmers for growing beets there and at the Grand Island factory. There are about 500 beet growers supplying this factory. They average some ten acres of beets each, making about 5,000 acres in all. The largest growers are: The Humphrey Sugar Beet Co., of Humphrey, Neb., 200 acres; H. A. Pasewalk, Norfolk, Neb., 90 acres; Conrad Wagner, Hadar, Neb., 50 acres, etc. A large part of the beets reach the factory by rail—some 1,200 acres being grown by 82 farmers in Platte County, south of Norfolk. 1,100 acres of these beets averaged 7.8 tons per acre yield.

Beets are received by the company on cars where loaded, so the factory stands any freezing en route. The frozen beets are all right if worked before they thaw. No beets for this factory are grown by irrigation, but contracts have been made for beets to be raised near Monroe, Platte County, by irrigation in 1898. In 1897 the yield of beets was greatly reduced by a drouth. In the early history of this factory, 1891 to 1893, it had to grow a large part of its own beets. Out of 2,500 acres of beets used in 1893, 1,500 acres were grown by the company, on rented land.

The farmers are largely Germans with some Russians, they retain largely the old country manner of dress and living, and women and children work with the men in the

fields. This applies to all kinds of farm work. In the larger beet fields, or where there is a lack of hands on the place, the work of thinning, weeding, hoeing, pulling and topping the beets is largely none by contract—by the row, or by the acre.

Farm laborers there are paid $15 to $20 per month and board. Per day, the usual rate is $1, and board. On contract work, the rate is 50 cents to $1, per day for boys, and $1, per day, for men and women, the workers boarding themselves and often camping near the fields. A man and team there are paid $2.50 per day, and a man and horse $1.75 per day; use of seeder costs 25 cents per acre. These figures are used in estimates of cost later on. Many farmers there raised beets also in Germany. Land rents there at $3.50 to $6 per acre—average about $5 per acre. Hauling is done by the ton. About one and a half to two tons is an ordinary wagon load of beets. Many days over 300 wagon loads are received at the factory, beside the car load lots. Cars are loaded to their visible capacity.

Very little alfalfa is raised around Norfolk and there is no systematic crop rotation. The following data are given for the business of this factory.

NORFOLK FACTORY.

Year.	Tons of beets.	Tons of sugar made.	Per cent sugar extracted from the beets	Pounds of sugar per ton of beets.
1891	8185	659	8.0	161.0
1892	10725	849	7.9	158.0
1893	22625	2054	9.0	181.5
1894 *	25633	2778	10.8	217.0
1895	27204	2486	9.2	183.5
1896				
1897	36270	3970	10.95	218.0

Their factory work began September 24, 1896, and September 13, 1897. It closed its run January 1, 1898, making the season 110 days. The average for 1897 is 7.25 tons of beets per acre. These data make the sugar extracted in

* The Grand Island factory did not run. A dry season and a short crop 14,000 tons of beets, tributary to the Grand Island district, are said to have been sent to Norfolk. The drought accounts for the richness of the beets and for the large percentage of sugar extracted.

1897, 1588 pounds per acre. The beets used in the run of 1897 are said to have averaged 13.6 per cent sugar in the beet and 81.5 per cent co-efficient of purity.

THE GRAND ISLAND, NEBRASKA, BEET SUGAR FACTORY.

The Oxnard Beet Sugar Company built its factory at Grand Island in 1890, making its first run that year. The factory is located about two miles west of Grand Island. They use about 2,500,000 gallons of water per day from the Wood river. The capacity is the same as at Norfolk, Nebraska, nominally 350 tons of beets per day. The machinery is said to be mostly of French manufacture. They do not use the Steffen process here. Part of the molasses made here is sent to Norfolk to be worked there by that process. This may explain since 1892 the higher per cent of sugar per ton of beets produced at Norfolk.

The general terms of the contract with the farmers there are the same as at Norfolk. The deductions made for freight on beets shipped to the factory are: 30 cents per ton, for 25 miles or under; 50 cents per ton, for over 25 miles and under 45 miles; and 80 cents per ton, for 45 miles and under 100 miles. Carload minimum is 24,000 pounds and they can be loaded to their visible capacity. Some 580 farmers contracted to grow about 5,000 acres of beets for this factory in 1897—averaging about 8.5 acres each. Among the large beet growers are Murr & Pinch, 125 acres; Sass Brothers, 115 acres; Theo. Hapke, 102 acres; Edmund Starke, 100 acres; H. G. Leavitt, 50 acres and J. N. Newell, 40 acres.

This factory uses 75 to 100 tons of Rock Springs slack coal per day for fuel. It also uses about 50 tons of lime rock per day. This comes from Nemaha county, Nebraska. It uses about one-half carload of coke per day and about a carload of sulphur during a season's run. The factory exceeds its rated capacity, and used October 24th, 1897, 377, tons of beets; other days 382, 383, 327 and 359 tons respectively. September 26th, 1897, they ran 397 tons of beets. They averaged last season, about 700 sacks of refined sugar per day. One day that season they produced 829 sacks of sugar. They started work September 6th, 1897, and closed down December 31st, 1897, making the total run 117 days. Including the "clean ups" and repairs, they averaged 333 tons of beets per day. 4,800 acres of beets were harvested for factory use, an average of 8.1 tons per acre. This would seem to leave only 200 acres, or say 4 per cent

short of the average seeded, which would be explained by imperfect stands, unmerchantable beets etc. The yield from the beets is about 1,400 pounds of refined sugar per acre.

This factory now employs 178 hands on its two twelve-hour shifts including 20 boys. The wages paid in the factory are, boys, 7½ cents per hour; men, 12½, 15 and 17 cents per hour; skilled labor by the month, at higher wages. Employes are paid in cash, every ten days or two weeks—at every "clean-up." All business is done through the local banks. About 20 per cent of the employes raise beets for the factory.

As at Norfolk, this factory grew a large part of its beets for the first two or three years. In 1891, it raised 1,250 acres of beets near Grand Island. In 1892, nearly half the total amount, or 1,183 acres, were raised by the company some 60 miles west of Grand Island; 450 acres were raised 12 miles distant and some 500 acres 100 miles away. In 1895, the farmers around Grand Island raised 700 acres of beets; in 1896, this was increased to 1,300 acres and in 1897, to 2,600 acres. About one-half the beets are still shipped in by rail, some coming (1897) from North Bend, Nebraska, 80 miles distant. The company has grown none of its own beets since 1892. It had applications from growers last spring to plant about 10,000 acres in beets, or double its requirements.

That locality was settled by a colony of Germans in 1857. Many of these are among the best farmers, and are men of means. There are some Russians and other foreigners, but perhaps one-half the farmers are Americans. Much of the hand labor is done there also by contract—by the acre, the row, or the ton.

The farm wages there range from $14.00 to $20.00 per month and board; by the day, $1.00 and $1.25. The women and children generally work on the contract plan. Many girls get $1.00 per day in the beet fields and prefer it to housework; boys 10 to 18 years are paid 50 to 80 cents per day. Man and team are counted at $2.50 per day there and man and horse at $1.75 per day. In exceptional cases, contracts could be made, as in Colorado, at $2.00 per day for man and team.

The same drought prevailed there in 1897 as at Norfolk, reducing the yield fully one-third, the average beets being 8 tons per acre. No crops are raised by irrigation there, and no factory beets are raised by that method. Land rentals there range from $4.00 to $7.00 per acre—perhaps $5.00 is a fair average.

The following data are given of the operations of this factory from the time it started in 1890:—

GRAND ISLAND FACTORY.

Year.	Tons of Beets used.	Tons refined Sugar Produced.	Per Cent Sugar made from Beets.	Pounds of Sugar per ton of Beets.
1890	5,000	368	7.36	147
1891	11,500	708	6.16 *	123
1892	13,000	1,055	8.12	162
1893	12,000	918	7.65	153
1894	14,000	Factory not run. Beets	shipped to Norfolk,	Nebraska, Factory.
1895	24,300	1,490	6.13 *	122
1896	30,100	2,516	8.36	167
1897	39,000	3,399	8.72	175
Averages.	18,612	1,493	7.50	150

This makes the extraction for 1897, 1,418 pounds of refined sugar per acre of land. The beets used in the 1897 run averaged, it is said, 12.87 per cent sugar in the beet and 79.5 per cent co-efficient of purity.

Special thanks are hereby tendered to Resident Manager Henry S. Ferrar for courtesies extended during the visit to Grand Island and since then; also for numerous beet analyses made without charge, for the Colorado growers.

GENERAL NEBRASKA NOTES.

Assuming the foregoing data, as to the operations at the two Nebraska Beet Sugar Factories, to be correct, we get from reported figures of the average sugar in the beets used by these factories, the following tables:—

	1890	1891	1892	1893
Per cent sugar in the beets, ...	15.20	13.30	14.40	13.30
Per cent sugar extracted from beets, ...	7.36	7.00	8.00	8.53
Per cent of sugar lost in manufacture	7.84	6.30	6.40	4.77

(This table would be of more value, had we also the average purity of the beets for the years stated, and the full details up to date.)

* The beets were low in sugar and in purity in 1891 and 1895, owing to cold, wet weather.

The United States data of rainfall for 14 years in the Loup valley, south of Norfolk, show an average precipitation of 23.74 inches. The distribution shows most of this to be between March and September of each year. This indicates a dry fall and winter, which are favorable for beet ripening and harvesting and also for the factory operations.

Dr. Max Hollrung, of Halle, Germany, shows the following mechanical analysis of the soils around the Nebraska sugar factories:—

	Per Cent Coarse Sand.	Per Cent Fine Sand.	Per Cent Finest Sand.	Per Cent Silt.
Grand Island (average)..........	0.72	10.85	63.38	25.05
Norfolk,....	0.20	3.49	52.00	44.40

THE LEHI, UTAH, BEET SUGAR FACTORY.

The Utah Sugar company was formed in 1890 and erected its factory at Lehi, Utah, beginning operations in 1891. It was the first beet sugar factory fully equipped with American-made machinery. It was installed by E. H. Dyer & Company, Cleveland, Ohio. It has made a fine record and greatly exceeds its rated capacity of 350 tons per day. In October, 1896, it worked 435 tons of beets in one day. It requires but 60 hands, including six boys, on each twelve-hour shift, where foreign factories of the same capacity use 100 to 150 hands per shift for the same hours' work. The 1897 run was made without any delay for breaks and repairs, and four tons beets more were cut per day than in 1896. The factory uses some 50 tons of Pleasant, or Castle Gate bituminous coal per day, costing $3.50 per ton. Its lime rock is hauled by teams and costs $2.00 per ton. About 18 tons per day are used. It is excellent rock, containing less than two per cent silicia. Cardiff, Colorado, coke is used there. The sulphur used comes from natural deposits some 100 miles south of Lehi.

The capital stock of this company is owned in Utah. It has a large number of stockholders, including many farmers. Its relations with the farmers are close and seem very pleasant. General Manager Thomas R. Cutler, Supt. C. A. Granger and George Austin, agriculturist, have been very courteous and all proper information was promptly given us. The factory is located two miles from Lehi and thirty miles south of Salt Lake City. The company owns about 139 acres of land around the factory, about 42 acres of this being covered by a reservoir, made by damming Spring

Creek. The factory water supply comes from this source and from four artesian wells in its yards. The water is fairly pure and contains but little alkali. The artesian water is the purer. The population of Lehi is some 2,500; altitude about 4,535 feet; annual rainfall reported to average some 14 inches.

In 1896 about 74 per cent of the beets came to the factory by rail, and 70 per cent. in this way in 1897. The minimum car rate on beets is $7.00, or 35 cents per ton, where 20 tons are loaded in a car. This rate extends to Payson, 35 miles, making there 1 cent per ton per mile.

From Springville—22 miles distance—the rate is about 25 cents per ton. Perhaps an average car rate is about 2 cents per ton per mile. The beets are mostly grown around Lehi and Springfield, but American Fork, Provo, Pleasant Grove, Mapleton, Payson, Riverton, Lake View, etc., are other shipping points. The Sugar Company stands about one-third of the freight charges on the beets. The Lehi Company raised beets on only about 200 acres of land in 1896 and 1897.

The season of 1896-97 was the banner year of this factory; 43,203 tons of beets were cut and 9,156,000 pounds of refined sugar were made.

The conditions around Lehi are almost ideal for growing beets and running a sugar factory. Fully nine-tenths of the farms are worked by the owners. The farms vary in size from five to forty acres, but there are said to be more farms under five acres than there are over forty acres. The farmers mostly live in the towns, which are but a few miles apart. The factory beets in 1897 were raised by about 700 farmers on 2,750 acres, thus averaging less than four acres to each grower. Mortgages on either farm or town property are very rare. There was no delinquent town tax at Lehi in 1897, and it is said that no tract of beet land has ever been sold at forced sale. There is more intense cultivation there, less expensive machinery, and more primitive methods in the field work. These latter increase the cost of production materially, but the families are generally large, and but little labor is hired on the farms. The women do not work in the fields, and the girls seldom work there, unless at home. Much of the hand labor in raising beets is done by boys. Crop rotation is practiced in an erratic way, and live stock is kept on most of the farms, so that manure is freely used in fertilizing. As the alfalfa is needed for stock feed it is seldom plowed under. All the beets for this factory are raised by irrigation.

The Utah Sugar company is said to have a capital stock of $1,000,000 and a bonded debt of $400,000. It is a very prosperous company. The refined sugar produced in 1896 is said to have cost $3,625 per hundred pounds. At a public meeting held in Ogden, Utah, November, 1897, to establish a beet sugar factory there, David Eccles said, among other things, "I am an Ogden stockholder in the Lehi sugar factory, and I may say that during the past two years they paid 37 1-2 per cent. dividend on the investment to the stockholders." The *Salt Lake Herald*, December 25, 1897, says: "The cost of the sugar company's plant at Lehi was over $500,000. It paid its stockholders no dividend for several years. Lately it has paid 10 per cent per annum dividends. Its stock is held stiffly at $8.00 per share, with few sellers. There has not been a delinquent tax payer in the vicinity of Lehi for years past."

We present the following analysis of the business of the Utah Sugar company. for the past seven years. The figures below are largely taken from an able report by Henry Michelsen, of Denver, Colo., on the beet sugar industry:

LEHI FACTORY.

Year.	Acres beets grown.	Average tons per acre.	Average per cent sugar in beets.	Average per cent purity.	Average per cent sugar extracted.	Tons of sugar made.	Pounds sugar per ton beets.	Refined sugar yield per acre.
1891	1500	6.6	11.	80.	5.52	550	110	733
1892	1500	6.5	11.	80.	7.50	737	150	983
1893	2755	9.7	11.6	79.5	7.65	2050	153	1488
1894	2850	11.5	12.7	80.2	8.41	2750	168	1930
1895	3300	11.5	13.5	81.5	9.66	3684	193	2233
1896	3200	13.5	13.9	82.5	10.60	4578	212	2861
1897	2700	6.75	13.2	82.	9.90	1838	198	1337
Averages.	2551	9.44	12.4	80.8	8.46	2312	169	1652

The land rentals around Lehi vary from $7.50 to $15.00 per acre. The conditions there, as to irrigation, soil, rainfall etc., are so similar to Colorado, that the study of this industry there is of peculiar interest. A dry spring, deficient water supply for irrigation, blight and insect depredations were all factors in cutting down the yield of beets in 1897 in Utah. The Utah Sugar Company cut 18.560 tons of beets in its factory run of 54 days in 1897 and made 3,676,700 pounds of refined granulated sugar.

The average rainfall for Utah is about 12 inches. It is about 16.5 inches near Salt Lake City. December is the wettest month, and the largest precipitation of the year is between December 1st and June 1st, each year; June is the dryest month. September shows more precipitation than any of the fall months. October and November average fairly dry weather, suitable for ripening and gathering the beet crop.

The soil shows a great diversity around Lehi, but is generally a heavier soil than the uplands of Northern Colorado. There is more sand in the soil near Springville. Many Lehi farmers claim the soil averages better for beets in the Springville district.

THE EDDY, N. M. BEET SUGAR FACTORY.

The Pecos Valley Beet Sugar Company erected this factory in 1896. The local stockholders have some $16,000 invested, but the larger part of the stock is owned by J. J Hagerman, of Colorado, and by wealthy manufacturers of Milwaukee, Philadelphia and New York City. A large part of the machinery was formerly in use in Canada. About $175,000 is now invested in the business. The factory is said to have a rated capacity of 225 tons of beets per day. The owners contemplate enlarging it this season, and 3,500 acres of beets are to be contracted to be grown for its use.

They use Thurber lump coal—some 30 tons per day. This is a semi-coking coal and makes a large amount of gas, soot and ashes. It costs $4.55 per ton, unloaded in bins at the factory. The blue limestone used, some nine tons per day, comes by wagon from Dark Canon, some 12 miles distant. It is 97 per cent carbonate of lime, about 3 per cent silica (a little too much) with a little iron, sulphate of lime and alumina and only a trace of magnesia. It costs $1.75 per ton at the factory. Pocahontas coke is used, from Memphis, Tenn. Sulphur deposits have been recently found, fifty miles distant, that will supply the factory needs next season.

The Pecos river water is very alkaline. The town of Eddy is supplied with domestic water by a pipe line from Dark Canon, two miles southwest. This supplies the factory when in operation also with a million gallons per day.

The factory cut an average of 134 tons of beets per day, the first season, and about 160 tons per day, during the last year's run. The company receives its beets "on board the cars at any station on the line of the Pecos Valley Railway," paying its own freight. It started the factory operations in November, 1896. and November 15, 1897.

The factory employs about 60 hands on each shift. A local stockholder says the company has estimated that the present working capacity of the factory can be doubled by an expenditure of $25,000. The present factory capacity is too small to secure the best results. The factory beets are raised at various points between Pecos City, Texas and Roswell, New Mexico. The Company raised 200 acres of beets in 1897. All its beets are raised by irrigation. Some 2,000 acres of beets were planted last spring and only about 1,700 acres were harvested. A fungus disease, blight and insect depredation, are given as causes of the small yield last season. One car load of beets in 1896 ran 24 per cent sugar in the beets and 92 per cent purity.

Supt. Vallez planted "mother" beets in the spring of 1897, raised beet seed, planted this seed and raised beets for the factory, all in the one season. Some 30 tons of "mother" beets were kept over and planted in February, 1898, to raise seed. They tested 19 per cent sugar and 84 per cent purity.

EDDY FACTORY.

	1866	1897
Acres of beets grown	1500	1900
Tons of beets produced	7800	5700
Average yield of beets ifi tons per acre	5.2	3.0
Per cent of sugar in beets	16.2	14.2
Per cent of purity of beets	82.0	80.0
Per cent of sugar extracted from beets	5.77	10.53
Pounds of sugar made per ton of beets	116	210
Pounds of sugar made per acre of beets	600	632
Tons of sugar produced	450	600
Days factory run	60	40

The population of Eddy is about 1,200. The Pecos Valley has an ample water supply, and a fine canal and reservoir system. The water assessments on lands is $1.25 per acre per year. The valley is a natural fruit garden, but is new, and lacks the farming population and, perhaps too the close careful cultivation, deep plowing, crop rotation, and knowledge of irrigation that pertains to the older farm districts of Colorado. It is doubtful also if beets do well when planted late, and grown during the extreme heat

of their summers. It may be possible to grow there two crops of beets—an early one and a late one. That will be tried this year, since the company advises the farmers to plant a part of their beet seed early and the remainder between June 15 and July 20. There is a large amount of gypsum in the soils there, and the lime rock crops out on the surface over large areas. The winters are mild and the records show at times high ranges of temperature in May, June, July and August. The average precipitation there is about 13 inches, but in 1897 it was 15.5 inches. The records show peculiar conditions—the rainy months being July, August, September and October. May is generally a dry month; in June there is more moisture. The record at Eddy for three years shows no precipitation in March, and very little in April, or November- The dry months are November to June inclusive.

COST OF GROWING SUGAR BEETS.

The investigation as to the cost to the farmers of growing the sugar beets has been very thorough. It covers the personal experience of 116 farmers, growing beets for the Norfolk factory, and also a large number around Grand Island and Lehi. It involves the question of labor, machinery, land rental, distance from factory, etc. In all cases the data cover all details from seed to delivery at the factory. The land rental is also included in each instance, whether the grower owns the land or is a tenant. The yield was obtained for 1897 and also for other years when possible, and the data enable us to figure the cost per acre and per ton, with the profit or loss. The figures obtained cover no allowance for cost of fertilizers, nor for profit on the beet tops, leaves and pulp. It was assumed that with our systematic crop rotation and alfalfa fertilizing in Colorado, the soil would ordinarily be rich enough.

In considering the figures obtained, we must remember that the beet crop of 1897 in Nebraska and Utah was only about sixty per cent of the ordinary yield, while in New Mexico the results did not warrant making any figures on cost of production. A larger tonnage would increase the cost per acre of topping and delivery to the factory. In general, however, the grower overestimates his yield, in giving the figures for 1897. By a like human tendency he may forget to mention some items of expense, or undervalue them. Where the factory does not receive all the beets before freezing weather, there is certain labor in putting the beets into pits, or silos, with a later uncovering and rehand-

ling. This matter and the taking of sample beets to the factory before digging, to ascertain if ripe, are uncertain items of expense. It is assumed that any beets raised, that were not of proper sugar content or purity, would be worth the factory price in Colorado for feed for cattle, sheep or hogs. The figures are made uniformly $4 per ton for the beets, as representing probable conditions here. The Nebraska growers received $5 per ton, one year, under a bounty law. The Utah growers were paid $4.25 per ton in 1896 and are to receive that price this year.

NORFOLK FACTORY.

The 116 beet growers, whose figures were obtained around Norfolk, claimed to have grown 1941 acres of beets of beets in 1897. The average yield given me was 9.4 tons (which at $4 per ton gives $37.60) average cost per acre $26.56, and average profit per acre $11.04, above all expenses, including delivery of beets to factory, rental, etc. This covers yields of from five tons to fifteen tons per acre and *net* results from a loss of $7.55 per acre to a profit of $29 per acre.

Believing in conservative figures, we think the yield to have been actually about eight tons average per acre there for 1897, while the average cost per acre may be put at $30, and the average profit at $2 per acre. It has been a hard year for the beet growers.

The contract price and usual cost of thinning beets at Norfolk is $4.00 per acre. The 18 pounds seed at $.15 was arbitrary, under the contract. Here is given the actual details from a German grower, Herman Wachter, as a typical instance, as he hires no help outside of his family and his beets were already dug, and delivered to the factory, thus verifying the yields:

SUGAR BEET GROWING, NORFOLK, NEB.

Name, Herman Wachter. Address, Norfolk, Neb.

Acres grown, 10 Year, 1897.

EXPENSES PER ACRE WERE:

Plowing	$ 1.50
Harrowing	
Rolling, or leveling	1.00
Seeds 18 lbs. @ 15 c	2.70
Seeding	.50
Cultivating, 6 times @ 30 c	1.80
Thinning	4.00
Hoeing, 3 times @ $2	6.00
Pulling	1.00
Topping	3.00
Hauling, 10 tons, 1 mile @ 21c	2.10
Rental of land per acre	5.00
Total cost per acre	28.60
Yield, 10 tons per acre @ $4	40.00
Net profit per acre	11.40

Cost per ton, $2.86. Net profit per ton $1.14.

OTHER CROPS GROWN BY ME WERE:

YEAR.	Acres grown.	Yield per accre	Cost per acre.	Profit per ton.	Profit per acre.
1891	3	16	30.00	2.13	34.00
1892	5	16	30.00	2 13	34.00
1893	14	17	31.00	2.18	37.00
1894	12	6	28.00	loss .67	loss 4.00
1895	12	14	29.35	1 90	26.65
1896	12	12	29.00	1.58	16.00

Oct. 11, 1897.

An increase of $1.00 in cost of topping, would have made Mr. Wachter's details for '97 typical of most of those obtained; the data vary generally in the number of times cultivating and hoeing, the yield, the hauling, and land rental.

GRAND ISLAND FACTORY.

At Grand Island the inquiry as to cost of growing the beets was less thorough, owing to a special request to look

into the question of cheap foreign labor, claimed to be used in this industry. The details, covering the growing of 459 acres of beets around Grand Island, Lockwood and Rivers, Nebraska, show an average reported yield of 9.5 tons (paying the grower, $38.00,) average cost per acre $28.73, and average profit per acre of $9.27. The actual average yield reported from the factory there for 1897 is 8.1 tons per acre. The yield reported there varied from five tons to twelve tons per acre, and the *net* results from $17.00 per acre profit to $12.00 per acre loss. Upon a review of these figures, the increased cost seems to be from the grower's living more distant from the factory—many shipping by rail. The average cost per acre may be fairly put at $30.00 there, the same as at Norfolk. The officials at both these factories put the cost per acre at the value of seven tons of beets, or $28.00 per acre.

Mr. R. M. Allen, of Ames, Nebraska, president of the American Sugar Growers' Society, and who raised for several years an average of over 500 acres of sugar beets, keeping the exact details of every item of cost, is firmly convinced, from his own records and experience, that sugar beets can be grown and marketed in Nebraska, at a cost of $30.00 per acre.

LEHI FACTORY.

George Austin, agriculturist for the factory at Lehi, gives the average cost to the grower of raising beets there for the past seven years, at $32.50 per acre. This does not, however, cover the land rental, which is from $7.50 to $15.00 per acre in that locality. We have averaged the rental at $10.00 per acre. The figures given me on the yield there average 10.1 tons per acre, but the actual average yield of all beets grown in 1897 was 6.75 tons per acre. From the figures given us, the average cost per acre there is $40.00. This may be assumed as fairly accurate, since there is added to the Nebraska cost, an average of $5.00 per acre increased rental, the cost of irrigation and a lack of proper machinery to do work quickly and cheaply. The one-row cultivator is often used instead of the four-rowed machinery, while the beet puller, used in Nebraska, is not used or known in Utah. As a comparative instance, a grower at Springville reports 20 tons of beets per acre. Prices of labor are the same there as in Nebraska, yet he reports a cost of $14.00 more per acre than the current figures around the eastern factories. Very little of the work is done by contract in beet growing in Utah.

PROFIT IN GROWING SUGAR BEETS.

In these average conditions we include the failures. The prospective beet-grower will probably judge that he can do better than the average. Large yields are regularly obtained by those farmers who do thorough, clean work. Twenty to thirty tons per acre are not uncommon yields, while over forty tons are reported, on good authority, as being of proper sugar content and purity.

In 1893, the Standard Cattle Company, of Ames, Nebraska, R. M. Allen, manager, raised 500 acres of sugar beets, and shipped 7,514 tons, over 100 miles to the Grand Island sugar factory. The average yield was 17.46 tons per acre. Among the yields were 5 acres averaging 30.2 tons, 28 acres averaging 22.7 tons and 59 acres averaging 20.5 tons per acre. After reserving the unmerchantable beets and topping the balance, the factory shipment averaged 15.02 tons per acre, *net* yield. After paying some $6,000.00 freight charges, there still remained a *net* profit of $6.25 per acre, besides over 1,200 tons of beets for cattle feed.

BEET CONTRACT

WITH

UTAH SUGAR COMPANY FOR 1898.

Acres........ Lehi, Utah................1898.

This agreement made and entered into this......day of ....1898, between the Utah Sugar Company (a corporation) the first party and.............................. of Lehi, second party, witnesseth: That the first party agrees to purchase from second party any and all beets he may produce (from seed furnished by the first party at the rate of 15 cents per pound) on the............acres of land hereby agreed upon, that do not weigh over 3½ pounds each and contain not less than 12 per cent sugar in the beet and that have a purity co-efficient of not less than 80 per cent, paying him therefor at the rate of Four Dollars and twenty-five cents per ton, delivered and piled in a proper manner under first parties' direction and unloaded at the Utah Sugar Company's factory at Lehi at cost of second party in first class condition, with the tops closely and squarely cut off at the base of the last or bottom leaf. The beets so delivered shall reach all the requirements of this agreement, and not contain any diseased, frozen, damaged, or improperly topped beets, nor any beet that weighs over 3½ pounds, otherwise the entire load so being delivered may be rejected. The

dirt weighed with the beets shall be tared and deducted from the gross weight by the first party in its customary manner, and shall be conclusive. Payment shall be made on or about the 15th day of each month for beets delivered the previous month. Said beets to be delivered only when ordered by the first party up to October 15th, 1898, after which time and until November 30th, 1898, second party may deliver beets as fast as they may desire if the said beets reach the required standard. To ascertain the quality of the beets, the first party shall at various times before and including November 30, 1898, and also at times of delivery, sample and polarize in the usual manner, the results of which shall be conclusive. If said beets have not reached the required standard by November 1st, 1898, tested in the usual and customary manner, and if after that time and up to time of the delivery attain it, then the first party may deduct 50c per ton from the contract price. After the 30th of November, 1898, it shall be optional with the first party whether or not it accepts any beets that have not been delivered. The second party hereby agrees to plant, cultivate, and harvest, in a husbandmanlike manner......acres of sugar beets on the land agreed hereon and protect them from the frost and sun while being harvested and delivered, and deliver them at the times, places, and in the manner set forth in this contract for the sum of Four Dollars and twenty-five cents per ton, to be paid as above set forth.

This contract is not transferable.

UTAH SUGAR COMPANY.

By........................

CONTRACTS BETWEEN FARMERS AND FACTORY.

We present the above 1898 contract of the Utah Sugar Company, as a sample form, which in its general terms has been used for years, and has satisfied the growers. The 1897 contract was identical, excepting that the price was then $4.00 per ton, and the beet seed 18 cts. per pound. This factory will use in 1898 about 33,000 pounds of German seed and 26,000 pounds of seed of its own raising. Home grown seed was used at Lehi and in the Pecos Valley, N. M. last year and produced better results than any imported seed. In the seven years the factory has run, it has not rejected over 2 per cent of the beets, on an average, for size and deficiency in sugar or purity. They have contracted 3,500 acres to be grown there to beets this year.

The two Nebraska factories use the same form of contract. That for 1897 agreed to pay $4.00 per ton, for 12-80

beets, $3.25 for 11–75 beets and $2.50 for 10–70 beets. The grower was to pay 15 cts. per pound for beet seed and plant 18 pounds. Beets of any weight are accepted. Their 1898 contract is changed. They agree to pay for beets containing 12 to 14.4 per cent sugar and not less than 78 per cent purity $4.00 per ton; for beets of equal purity, and 14.5 to 15.4 per cent sugar $4.25 per ton and 25 cents per ton additional for every like per cent of sugar over 15.4 per cent, and purity not less than 78 per cent. Then 11–78 beets are to be $3.50 per ton; 10 70 beets $3.00 per ton. Fifteen cents per ton reduction for every degree (or fraction thereof) of purity below 78, and no beets to be accepted containing less than 10 per cent sugar and of 73 per cent purity. The contract at first provided that if Hawaii is annexed to the United States, a reduction of 50 cents per ton is to be made from all the above prices; but this clause was cut out. The growers may also have a chemist check the analyses at their own expense.

The other Oxnard factory, operated by the Chino Valley Beet-Sugar Company, of Chino, California, makes a reduction in its contract of 15 cents per ton for each and every degree of purity below 78 per cent, and of 50 cents per ton for each and every per cent of sugar below 12 per cent, down to and including 10 per cent, below which no beets are to be received. The company pays $3.50 per ton for beets with 12 per cent sugar, and 20 cents per ton increase for every additional per cent of sugar in the beets. It reserves the right to reject very large beets. The growers are allowed to have a representative in the tare room, and the weigh room, and a check chemist in the laboratory.

The Pecos Valley Beet-Sugar Company pays under its contract $4.00 per ton for 12–80 beets.

The Spreckles Sugar Company, of Watsonville, California, has a very simple contract. It provides beet seed at 10 cents per pound. It rejects beets weighing over five pounds, and deducts 5 per cent tare in all cases, for dirt etc. It pays $4.00 per ton for all beets, and makes no limitations as to sugar or purity, except that they shall be fit for sugar-making purposes.

GENERAL CONTRACT NOTES.

All beet contracts are for one year only, and define the acreage of beets to be grown, agreeing to take all that are as per contract. In all beet contracts the grower is to be paid the 15th of each month for all beets delivered the previous month. All factories provide the beet seed to be

planted and supervise the growing of all beets by their field agent. The factory determines when the beets are ripe, by chemical tests of sample beets delivered by the grower, and directs when they shall be dug and delivered.

THE LABOR PROBLEM.

Perhaps the most serious problem involved in the growing of sugar beets, is the large amount of hand labor required, a part of which, the thinning and weeding, must be done on the hands and knees. The topping of the beet is another tedious matter. The hand labor, on the knees in the dirt, is a factor which the average adult American farmer will personally reject. The natural inference, in seeing women, children, Germans, Russians, Chinamen, Japanese and Mexicans doing this hand work, is that it is *cheap labor, or foreign contract labor*, and that such cheap labor is a necessity to produce the beets and sugar at the current market price. The investigation does not warrant any such idea. It is not a fact. It is simply an humble occupation, rejected by those tillers of the soil who can do better in raising other special crops. The prices paid the Chinese and Japanese for work in the beet fields of California, are reported to be fully equal to Nebraska and Utah wages for similar work. The beet growers of Anaheim and Chino employ white labor exclusively and profitably. The price paid per day in the beet fields, is everywhere the same as that paid for other farm work. On contract work it often exceeds the ordinary farm wages, and it is reported that some Chinese laborers have made $3.00 per day in this way, on contract work in the Pajaro Valley.

The beet-sugar factories in Nebraska faced this problem in the first three years of their operation. It threatened their very existence, and endangered the million dollars invested. It was solved by bringing in Germans and Russians from other parts of the state, who took the work gladly at current prices.

It has been the serious problem to every factory, how to get the labor to raise the proper beet tonnage. At current Nebraska contract prices, of $4.00 per acre to thin the beets, and the same amount to top them, this pays $8.00 for *hand labor*, on every acre of beets grown. It requires work equal to one person six days at $1.33 cents per day. Each Nebraska factory requires the beets from 5,900 acres of land. Leaving out any hand hoeing, we have necessary then, for each beet-sugar factory, hand labor equal to that of 30,000 persons for one day! All thinning too must be done in less

than thirty days, requiring, therefore, more than five hundred persons to be at this work during that month.

COST OF MAKING BEET SUGAR.

Few facts are made public regarding this important question.

The figures obtained are incomplete. The results in 113 German beet-sugar factories in 1889-90, showed the mean capital invested in each factory to be $193,400 and the mean *net* profit for each factory, $34,240, or nearly 18 per cent. The average sugar product is not stated. These factories used an average of 10,503 tons of beets. The profit per ton of beets was $3.26.

Unofficial data from Lehi, Utah, show the 1896 expenses to have been:—

Cost of 43,203 tons beets	$190,000.00
Labor in factory	32,000.00
Coal, coke, etc.	30,000.00
Limestone, sacks, filter cloths, oil etc.	25,000.00
Interest, 8 per cent on $400,000	32,000.00
Salaries, insurance, repairs etc.	20,000.00
Total	$329,000.00

This makes the cost of the sugar $3.60 per cwt.

FACTORY CUSTOMS.

The grower is required to take sample beets to the factory at intervals in the fall, that the chemist may determine when they are ripe. At some factories the beets can only be delivered when required. They may be ripe, but they cannot be dug. A rain may come, followed by warm weather, and the beets may begin a second growth. Then a test may show they are below standard, in which case they may be taken at a lower price, or they may not be taken at all, *i e*, they may be too low in sugar and purity. If the factory delay its call until freezing weather, then the beets must be pulled and covered in pits, at the grower's expense for handling, and perhaps some loss by freezing.

A tare is deducted at all factories for dirt and any improper topping of the beets. A sample lot is taken usually from each wagon load, and several samples from each car load, and the dirt is removed with brushes or a dull knife and the beets are properly topped, if necessary. The loss in weight determines the tare per ton.

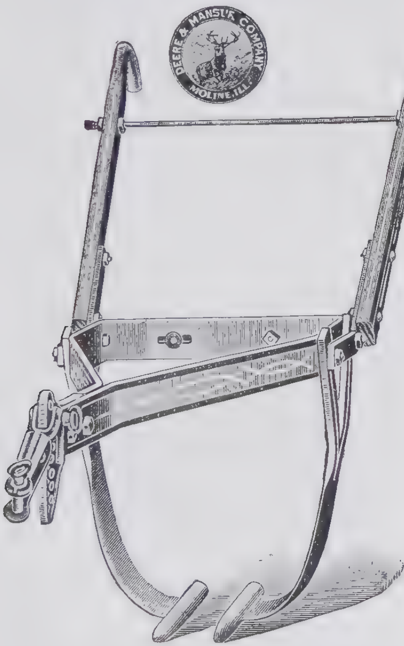
When the beets are bought on a value based upon their

sugar percentage and purity, the grower sometimes thinks the factory is unjust, and rates the beets too low. A check chemist is permitted the growers at such factories, but he is seldom employed, especially if the contract states that the factory test shall be final.

Some of the factories furnish quite an amount of the seeders, cultivators, and pullers, charging a rental. The Lehi factory seeds most of the land for the growers, charging 40 cents per acre, besides the seed.

BEET MACHINERY.

The best machinery we saw was at Norfolk, Nebraska; there are three seeders used there. The Jewell four row beet planter is made by Jewell Brothers, Platte Centre, Neb.



The Superior Drill Co., of Springfield, Ohio, al a four row beet drill; and the Moline Plow Co., of Moline, Ill., sells a two row beet seeder and a two row beet cultivator. The Deere & Mansur Co., Moline, Ill., sells two varieties of two row beet cultivators. They also sell an adjustible beet puller, a cut of which is shown herein. This is an adaptation by Theo. Hapke, of Grand Island, Neb., from the more cumbersome beet pullers used in Germany. A puller is made by the local blacksmith at Norfolk, Neb.,

which some prefer. The forks are slightly curved and narrowest at the center.

FACTORY REQUIREMENTS, MACHINERY, ETC.

The Sugar company at Norfolk, Neb., was given a bonus of $100,000 cash and fifty acres of land to build and operate its factory there. The Grand Island company is said to have been given also a bonus of $100,000. The Utah Sugar company was given as a bonus, quite an amount of land for the factory site, including a reservoir covering some 42 acres, together with all water rights and privileges connected with it.

The first necessity of a beet sugar factory is that it have a sure supply of good beets. A modern factory of the minimum size for economy now built, will cost some $300,000, besides the capital to run it. This would use 350 tons of beets per day, and would need beets to be grown on from 3,000 to 5,000 acres of land. Allowing for crop rotation, this means that some 10,000 to 15,000 acres of good beet land should be fairly near a sugar factory. Such a factory would use some 50 tons of coal, and say 20 to 50 tons of good limestone per day. The lime rock must be very free from silica, iron, magnesia, or sulphate of lime. It must be nearly pure carbonate of lime. One of the verv necessary needs is a fair amount of good water, not alkaline, for steam purposes, diffusion process, praying the sugar, etc. It is claimed by French sugar journals that it is never desirable to use in a diffusion battery, a water containing more than one part of solid matter in two thousand.

The following is an average of 25 analyses of the water of the Pecos river, at Eddy, New Mexico, showing the solids in 100,000 parts of water.

Chloride of sodium	100
Carbonate of lime	10
Sulphate of lime	130
Carbonate of magnesia	3
Sulphate of magnesia	50
Silica	2
Alumina and sesqui-oxide of iron	3
Sundries	2
	300

A like average of the analyses of 25 samples of water from Dark Canon, shows in 100,000 parts of water, solids as follows :

Carbonate of lime	20
Sulphates of lime and magnesia	28
Chloride of sodium	1
Silica, alumina, etc	1
	50

FEEDING SUGAR BEETS AND BEET PULP.

Volumes might be written on the value of the sugar beets for food. They are a table delicacy that should be grown in every garden. As food for cattle, sheep and hogs, they may be profitably grown by every farmer. One farmer pertinently says, "There is no better factory for the profitable use of sugar beets than running them through the live stock on the farm, and converting them into milk, meat and manure." An analysis shows the dry material contains about the same nitrogen, free extract, and crude protein and about one-half the crude fat of ground wheat. In Utah they are largely used as hog feed, and it is even claimed that their use will prevent the hog cholera.

The beet chips (tops) and leaves are also largely fed where the beets are raised for the factories. In France the beet chips are worth $2.70 and the leaves $1.30 per ton.

The beet pulp produced at the sugar factories is of especial value as a food for live stock. At the Nebraska factory it is given away free. At other factories it is sold for 50 to 75 cents per ton. At or near all the factories a very large number of cattle and sheep are fed. It is a fine feed for dairy cows, but care must be taken not to feed an excess with alfalfa hay, as it is too fattening. It has proven to be especially good food for sheep, when used with alfalfa hay.

The factories produce in pulp about 50 per cent in weight of the beets, or say 180 tons per day at Lehi, Utah. In the silos it loses about 10 per cent more water by the natural compression and is like a soft cheese. In Nebraska the pulp contains about .5 per cent sugar and in Utah about .3 per cent sugar.

Prof. H. W. Wiley writes, January 10, 1898, "Beet pulp is not a complete ration by itself, but needs to be fed in conjunction with a rich nitrogenous food, such as cotton or linseed meal, peas, beans or clover. Beet pulp is easily preserved in silos, does not tend to ferment, and can be kept indefinitely, when properly preserved."

Prof. Wiley in this letter gives the composition of a beet pulp containing 60 per cent of water, as follows:

	Per Cent.
Moisture,	60.00
Ash,	3.21
Crude protein,	2.98
Fiber,	8.72
Non-nitrogenous matter,	24.77
Fats,	.27
Total,	99.95

At the Lehi sugar factory the pulp is carefully stored in immense silos built in the ground, without any covering. About half a per cent in weight of salt is sprinkled on every layer of pulp as it goes into the silos. These two silos are built of heavy timber and are 10 feet deep 20 feet wide on the bottom, 24 feet wide on top and 800 feet long. Storage capacity of both, 14,000 tons of pulp. They are floored.

Tracks are run into the center of these silos, which are open at one end. A water-way is built under the center of the tracks, to carry away the water draining from the wet pulp. The tracks run between the feed yards, and horses pull the small cars out of the silos. The pulp is fed in open troughs and the alfalfa hay from racks. The pulp is fed to both cattle and sheep. The stock have always access to plenty of hay, pulp and water. *They never feed a pound of grain in fattening the stock,* unless the pulp gives out. In 1895 they fed the pulp which had accumulated for three years. Both here and at Eddy the sheep seemed especially fond of the dry pulp from the top of the silos.

The cattle at Lehi were put on this feed November 3, 1897, and the sheep about two weeks later. The cattle get on full feed in about ten days, and the sheep at once. They were a rough lot of cattle but many were then (Dec. 20) ready for the butcher. The sheep were mostly May lambs, with about 200 head of broken mouthed ewes. They were in splendid condition, not ten poor sheep in the lot. Supt. George Austin says that they feed about a hundred days; that cattle consume about 15 pounds of hay and 100 pounds of pulp per day, and the sheep two pounds of hay and three to four pounds of pulp per day. He said from the way the sheep were gaining they would reach the market averaging 90 pounds per head. (They were weighed into the yard at 60 pounds per head.) He also says that the pulp gives the best results after fermenting in the silos for thirty days, and should not be fed before then. He says that if there be any

criticism on this feed, it is that the stock *get too fat*, but that the sheep top the Chicago market and find ready sale also in foreign markets. They have not nearly enough pulp to supply the local demand.

At the Eddy, N. M. factory stock yards they are feeding only sheep this season. The sheep there are said to use per day eight pounds of pulp and one pound of hay per head per day.

From the Grand Island factory pulp is furnished to feed sheep at Shelton, Nebraska. Ed Graham, (manager for E. F. Swift) and Matthews and Stockwell are feeding there. The latter wrote Jan. 1, 1898, that they are feeding 25,000 head of lambs on the pulp; that they consume about three pounds per head per day, and that the freight on pulp is 30 cents per ton from Grand Island.

John Reimers has fed pulp to cattle for three years at Grand Island. He uses about 50 pounds of pulp, 20 pounds corn meal, a little bran, and oil cake, and the usual amount of hay per head per day, as a full ration.

Hake Bros., of Grand Island, Neb., fed 200 head of cattle and 20,000 head of lambs on beet pulp, at the factory feed yards this season. They have fed cattle on beet pulp, both there and at Norfolk for several years. They feed about 80 pounds of pulp and 12 to 20 pounds of corn meal per head per day. They say that the cattle coming to the feed yards from the ranges, find the moist pulp a great help in making the change from grass feed to hay; say the sheep get on a full feed of pulp within 24 hours, and that the lambs use about 4 pounds of pulp and 1 to 1½ pounds of corn meal per head per day, mixed, beside the hay.

W. H. Butterfield fed 1,000 head of cattle on pulp at the Norfolk, Neb., sugar factory yards this season. Has fed there several years. He feeds about 70 pounds pulp mixed with 15 pounds corn meal per head per day; also all the hay they will eat. Says the steers on this feed use only about a ton of hay per head during the entire feeding season; says beet pulp is an especially fine feed for sheep.

CONCLUSIONS.

That the beet sugar industry is still in its infancy, or in the experimental stage, both as to the factory operations and the growing of sugar beets by the farmers. American inventive genius has not yet found enough demand for this special factory and farm machinery to fairly grasp the problems and solve them, namely: How to simplify the mechanical and chemical methods and save the necessity of the pres-

ent great cost of beet sugar factories, and how to reduce the handlabor in the fields, or do away with it entirely.

That a sure supply of sugar beets may be obtained every year for factory uses, where raised by careful, thorough farmers, having an ample supply of water for irrigation.

That many localities in Colorado and adjoining states have every qualification necessary to establish a paying beet sugar factory, excepting the laborers to raise the beets.

That a single beet sugar factory will produce enough beet pulp in a single season's run of 100 days, to fatten 35,000 head of sheep—the pulp filling the place of hundreds of cars of corn, now shipped to this State every fall and winter. That this pulp would be produced just when needed for feeding, and should be a stimulus to that industry and a profit to a Colorado factory.

That to become a leading national industry, it must be so simplified as to be beyond political hazard and the need of a protective tariff.

That a closer relation must obtain between the producer of sugar in the field and those who extract it, at the factory, so that the profit may be believed to be more equitably shared. The present enormous expense of factory construction invites this, since the beet grower risks but a few dollars in farm machinery, and can stop growing beets any time, while the greatest risk to the factory, under proper management, is a shortage in its supply of beets.

That when the conservative Colorado farmer undertakes to grow sugar beets commercially, he will as surely succeed and top the mark and market in that industry, as he has in the growing of wheat, potatoes, fruit, and melons, and in the feeding of sheep on alfalfa hay.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 43.

(Technical Series, No. 3.)

I. Colorado Lepidoptera.

II. A Few New Species of Deltocephalus and Athysanus from Colorado.

III. A List of Original Types, etc., in Collection.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MARCH, 1898.

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COLORADO LEPIDOPTERA.

CLARENCE P. GILLETTE.

Since entering upon my duties as Entomologist of this Station, I have kept records on all our captures of insects within the State. These records contain notes in regard to dates and localities of captures, names of collectors, food-plants, altitudes, and such other data as might be considered of interest.

There have been requests that these records be published for the information of those who are interested in entomology, but who cannot have access to our collections and records. Bulletin 31, gave our records upon the order *Hemiptera*, and in the present paper are given our records upon the order *Lepidoptera*, so far as the species have been determined.

In this connection, I wish to state that I am greatly indebted to the following specialists for the determinations of the great majority of the species here reported: Dr. J. B. Smith, Dr. C. H. Fernald, Rev. Geo. D. Hulst, Mr. David Bruce, and Dr. Henry Skinner.

Opposite each species in the following list will be found one or more of the Accessions Catalogue numbers. By looking up these numbers in the list of Accessions Catalogue numbers, following the list of names, the records of each will be found:

LIST OF SPECIES WITH THEIR ACCESSIONS CATALOGUE NUMBERS.

RHOPALOCERA.

Family NYMPHALIDAE.

Danais archippus—1001, 791.
Danais berenice—2806.
Danais strigosa—2806.
Agraulis vanillæ—2806.
Euptoieta claudia—564, 628, 691, 1002, 2196.
Argynnis leto—2806.
Argynnis cipris—638, 655, 2686.
Argynnis electa—785, 787, 788, 791.
Argynnis hesperis—640, 790, 791, 2196, 2214, 2216.
Argynnis halcyone—788, 791, 2143, 2149.
Argynnis nevadensis, var. meadii—788.
Argynnis edwardsii—785, 787, 818
Argynnis liliana—781.
Argynnis eurynome—684, 787, 792, 1368.
Argynnis triclaris—785, 2171.
Argynnis helena—2806.
Argynnis freya—687.
Melitæa augusta—537, 787.
Melitæa anicia—544, 337, 564, 681, 687.
Melitæa anicia, var. eurytion—687.
Melitæa nubigena—2806.
Melitæa acastus—567, 1002.
Melitæa palla—2806.
Melitæa chara—2806.
Melitæa minuta—1, 786, 1002, 2112, 2214, 2617.
Melitæa brucei—2806.
Phyciodes nycteis—355, 360.
Phyciodes drusius—360, 564.
Phyciodes carlota—360, 564, 659, 2096, 2463, 2465, 2499.
Phyciodes tharos—537, 559, 564, 602, 2565.
Phyciodes pratensis—388, 554, 687, 2565.
Phyciodes mylitta—2289.
Grapta satyrus—317, 785, 1531, 2096.
Grapta umbrosa—2198
Grapta zephyrus—655, 785, 795.
Vanessa antiopa—35, 209, 719, 1002.
Vanessa californica—738.
Vanessa milbertii—548, 689, 791, 1002, 1531.
Pyrameis atlanta—741, 785, 1002.
Pyrameis huntera—1002
Pyrameis cardui—786, 791, 1002, 1115.
Pyrameis carye—1426, 2565.
Junonia cœnia—2806.
Limenitis ursula—2806.
Limenitis ursula, var. arizonensis—1390.
Limenitis weidemeyerii—537, 564, 638.
Limenitis dissippus—566, 1002.
Aptura montis—2196.
Anæa andria—2806
Debis portlandia—2806
Neonympha canthus—2806.
Neonympha henshawi—1002.
Neonympha eurytris—2806.
Cœnonympha ochracea—537, 567, 687, 738, 1733, 2143, 2198, 2214, 2227, 2565, 2684.
Cœnonympha pamphiloides—544, 2565.
Erebia callias—785, 788, 791.
Erebia epipsodea—547, 687, 720, 730, 738, 788, 1704.
Erebia epipsodea, var. brucei—2806.
Erebia magdalena—687, 729.
Hipparchia ridingsii—564, 587, 1002, 2683
Hipparchia dionysus—2806.
Satyrus nephele—638.
Satyrus nephele, var. boopis—686, 1368.
Satyrus nephele, var. ariane—638, 1002.
Satyrus meadii—2806.
Satyrus sylvestris, var. charon—638, 655, 1002.
Chionobas chryxus—548, 567.
Chionobas ivallda—2806.
Chionobas uhleri—1002.
Chionobas taygete—726.
Chionobas jutta—2806
Chionobas semidea—2171.
Chionobas brucei—726, 738, 1706.
Libythea bachmani—2806.

Family LYCAENIDAE.

Lemonias virgulti—2806.
Lemonias nais—655, 2617.
Thecla crysalus—2250.
Thecla halesus—2806.
Thecla melinus—1002, 2091, 2096, 2465.
Thecla dryope—2806.
Thecla calanus—2196.
Thecla sæpium—789.
Thecla nelsoni—2806.
Thecla spinetorum—2806.
Thecla blenina—2806.
Thecla behrii—638, 655, 786, 791.
Thecla augustus—360, 424, 2465.
Thecla henrici—60, 360, 1559, 2078, 2091, 2465.
Thecla eryphon—60, 424, 467, 2096.
Thecla niphon—2806.
Thecla affinis—564, 2112, 2465, 2565.
Thecla dumetorum—360, 2078, 2112, 2465, 2565.
Thecla sheridanii—245, 467, 1559, 2078.
Thecla titus—637, 638, 780, 791, 1002, 2207, 2250.
Chrysophanus virginiensis—2806.
Chrysophanus xanthoides, var dione—599, 602.
Chrysophanus editha—1704.
Chrysophanus thoe—1002.
Chrysophanus helloides—1002, 537, 684, 738, 785, 1704.
Chrysophanus helloides, var. florus—687, 785.
Chrysophanus snowi—2806.

Chrysophanus rubidus—581, 636, 684, 720, 1959.
Lycæna heteronea—537, 790, 793, 1734.
Lycæna lycea—337, 537, 541, 685, 1732, 1734, 2112, 2214, 2509, 2565, 2586.
Lycæna dædalus—2806.
Lycæna lygdamas, var. oro—424, 467, 1114, 2078, 2091, 2465.
Lycæna sagittigera—2806.
Lycæna aquilo—735, 2171.
Lycæna battoides—2565.
Lycæna shasta—45, 360, 1145.
Lycæna melissa—51, 559, 602, 684, 691, 1002, 1174, 2143, 2215.
Lycæna acmon—792, 2198, 2565.
Lycæna pseudargiolus, var. violacea—602.
Lycæna pseudargiolus, var. neglecta—360, 1114, 2091, 2112.
Lycæna comyntas—360, 2112, 2216, 2465.
Lycæna isola—1002.
Lycæna marina—2806.

Family PAPILIONIDAE.

Neophasia menapia—1002.
Pieris beckerii—337, 548, 566, 2294.
Pieris sisymbri—360, 424, 2078, 2091, 2096.
Pieris protodice—559, 674, 732, 738, 785, 791, 1002, 1706, 2227.
Pieris bryoniæ—2684.
Pieris napi, var. oleracea-æstiva—684, 687, 735, 738, 787, 1700.
Pieris rapæ—1002, 747, 759, 1559. Extremely abundant.
Nathalis iole—892, 1002, 2617.
Anthocharis olympia—360.
Anthocharis ausonides, var. coloradensis—360, 424, 492, 687, 1559, 2091, 2096, 2465.
Anthocharis julia—567.
Anthocharis eubule—1002.
Meganostema cæsonia—2806.
Colias meadii—687, 2171.
Colias elis—785.
Colias eurytheme—541, 738, 741, 785, 818, 1002, 1368.
Colias eurytheme, var. eriphyle—564, 674, 686, 791, 793, 1002, 1368.
Colias eurytheme, var. alba—1002, 2258.
Colias philodice—537, 541, 544, 674, 684, 688, 788, 818.
Colias alexandra—1368, 1704, 2198.
Colias scudderii—687.
Terias nicippe—1002.
Parnassius smintheus—548, 564, 644, 687, 787, 1368
Parnassius smintheus, var. behrii—644, 793, 1002, 2168, 2227.
Papilio eurymedon—644, 2112.
Papilio rutulus—566, 567, 2096
Papilio daunus—1, 428, 2565.
Papilio troilus—1002.
Papilio oregonia—2806.
Papilio zolicaon—1002, 2078.
Papilio indra—1002, 2096, 2143, 2565.
Papilio bairdii—2806.
Papilio asterias—1002, 1374, 1375, 1376, 1432, 1448.

Family HESPERIDAE.

Ancyloxypha numitor—2806.
Thymelicus poweschiek—537, 559.
Pamphila taxiles—581, 1002.
Pamphila colorado—564, 780, 1174, 2169.
Pamphila nevada—687, 787.
Pamphila manitoba—537, 564, 644, 2169, 2196.
Pamphila juba—2196.
Pamphila napa—1217, 2298.
Pamphila uncas—1002.
Pamphila rhesus—2465.
Pamphila agricola—1418.
Pamphila snowi—2684.
Pamphila mystic—1217.
Pamphila cernes—541, 1217.
Pamphila verna—2617.
Pamphila vestris—564, 1002, 1209, 2565, 2617, 2684.
Pamphila bimaculata—581.
Amblyscirtes vialis—2465.
Amblyscirtes ænus—739, 2564.
Pyrgus ericetorum—2806.
Pyrgus tessellata—818, 1002, 2206, 2509.
Pyrgus cæspitalis—60.
Nisoniades brizo—2112.
Nisoniades icelus—60, 388, 467, 544, 548, 655, 738, 1002, 2091.
Pholisora catullus—360, 1002, 2096, 2112, 2206, 2524.
Pholisora hayhurstii—564, 684, 739.
Eudamus tityrus—556, 559, 1002.
Megathymus yuccæ—537.

HETEROCERA.

Family SPHINGIDAE.

Hemaris rubens—687, 1145.
Hemaris senta—2806.
Hemaris brucei—2806.
Lepisesia guaræ—1166, 1649.
Deilephila gallii—535, 556.
Deilephila lineata—808, 818, 830, 1002, 2563, 2653, 2659.
Chœrocampa tersa—2806.
Sphinx drupiferarum—1002.
Sphinx gordius—2806.
Sphinx vancouverensis—
Sphinx chersis—1922.
Sphinx oreodaphne—2806
Sphinx lugens—1002.
Triptogon modesta—1, 740, 1402, 2508, 2553, 2604, 2610, 2654, 2659, 2666, 2679.
Smerinthus geminatus—535
Smerinthus cerisyi—565, 1002, 2565.
Paonias myops—2806.

Family SESIIDAE.

Albuna montana—687, 785.
Sannina exitiosa—693.
Sesia tipuliformis—85, 1002, 1220
Pyrrhotænia coloradensis—1002.

Family THYRIDAE.

Thyris montana—602.

Family AGARISTIDAE.

Alypia octomaculata—86, 351, 555, 1002.
Alypia ridingsii—687, 1700.

Family SYNTOMIDAE.

Anatolmis grotei—1002, 1804, 2248.
Lycomorpha miniata—2207.

Family PYROMORPHIDAE.

Harrisina coracina—401, 1165, 1659, 2123.

Family CTENUCHIDAE.

Scepsis fulvicollis—778, 1002, 1440, 2221, 2610, 2679, 2719, 2721, 2722, 2730, 2737, 2743, 2748, 2750.
Ctenucha venosa—1002.

Family PERICOPIDAE.

Gnophæla vermiculata—785, 790, 2179.

Family LITHOSIIDAE.

Lithosia bicolor—685, 790, 2570, 2654, 2659, 2666.

Family ARCTIIDAE.

Crocota rubicundaria—112, 564, 655, 2165, 2610, 2620, 2654.
Crocota brevicornis—627.
Emydia ampla—2806.
Callimorpha lecontei—2806.
Epicallia virginalis—652.
Euprepia caja—791.
Arctia intermedia—1002.
Arctia rectilenia—2652, 2668.
Arctia elongata—
Arctia blakei—2737.
Arctia flavorita—2806.
Arctia dahurica—
Arctia nevadensis—2806
Arctia incorrupta—1002, 2743—
Arctia bolanderi—2225, 2693.
Arctia docta—705.
Arctia ochracea—2806.
Arctia geneura—302.
Arctia arizonensis—2806.
Arctia determinata—2806.
Arctia speciosa—2685, 2750
Arctia pallida—2806
Arctia virguncula—1704.
Leptarctia californiæ—280, 360, 1606, 2091, 2465.
Nemeophila petrosa—687, 2168, 2227, 2755
Pyrrharctia isabella—535, 536.
Phragmatobia rubricosa—334, 2552, 2654, 2670, 2685.
Antarctia brucei—2204.
Leucarctia acræa—334, 371, 428, 436, 523, 535, 562, 807, 1002, 2462, 2573, 2663.
Spilisoma virginica—431, 474, 535, 536, 565, 2110, 2404, 2550.
Hyphantria cunea—556, 672, 1575, 1576, 1577.
Euchætes spraguei—689.
Euchætes egle—690.
Euchætes oregonensis—602, 2610, 2625
Arachnis picta—420.
Arachnis citra—2806.
Ecpantheria permaculata—494, 567, 1714, 2610.
Halisidota tessellata—636, 565, 689, 2604, 2610, 2637, 2647, 2691, 2738.
Halisidota maculata—254, 523, 2621, 2676.
Halisidota labecula—2806.
Halisidota argentata—2806.
Halisidota subalpina—2806.
Halisidota ambigua—2806.
Halisidota occidentalis—2806.
Halisidota trigona—2806.

Family NOTODONTIDAE.

Ichthyura inclusa—334, 2171, 2469, 2471.
Ichthyura inornata—2806.
Ichthyura albosigma, var. specifica—2621, 2662.
Ichthyura brucei—2806.
Datana perspicua—1226.
Hyparpax venus—2806.
Hyparpax aurostriata—2806.
Gluphisia trilineata—535.
Gluphisia ridenda—82, 428.
Lophopteryx notaria—536, 1002, 2118, 2573.
Notodonta stragula—2614, 2625.
Odemasia perangulata—2806.
Cerura albicoma—334, 2101.
Cerura cinerea—535, 1002, 1900, 2567, 2570, 2573, 2578.
Cerura candida—2806.

Family SATURNIIDAE.

Attacus co umbia—2423.
Attacus gloveri—1002.
Telea polyphemus—1002.
Saturnia galbina—2806.
Hyperchiria io—107.
Coloradia pandora—2693.

Family BOMBYCIDAE.

Pseudohazis eglanterina—1002.
Hemileuca maia—1002.
Clisiocampa fragilis—112, 115, 118, 125, 623, 693, 739, 893, 1002, 1715, 2178, 2657, 2685.
Clisiocampa thoracica—739.
Gastropacha mildei—690.
Gloveria arizonensis—1002.

Family COSSIDAE.

Hypopta bertholdi—2806.
Hypopta henrici—2806.
Cossus brucei—2806.
Prionoxystus robiniæ—2567, 2604, 2621, 2662.

Family THYATIRIDAE.

Pseudothyatira cymatophoroides—673, 683, 690.

Family NOCTUIDAE.

Panthea gigantea—2806.
Panthea palata—2806.
Raphia coloradensis—535, 629.
Raphia frater—2614.
Charadra deridens—2806.
Merolonche spinea—2806.
Acronycta furcifera—2048
Acronycta felina—2806.
Acronycta lepusculina—431, 488, 535, 565.
Acronycta americana—101, 438, 671, 683.
Acronycta dactylina—539, 690, 1002, 2578.
Acronycta luteicoma—523.
Acronycta brumosa—334.
Acronycta sperata—535.
Acronycta barnesii—2806.
Acronycta parallela—1127, 2526.
Cerma olivacea—2693.
Rhynchagrotis vittifrons—2806.
Rhynchagrotis mirabilis—1743.
Rhynchagrotis minimalis—2737.
Rhynchagrotis placida—1261, 2164, 2235, 2743, 2750, 2751, 2753, 2748, 2708.
Pachnobia littoralis—2168, 2198, 2224.
Agrotis aurulenta—2806.
Agrotis ypsilon—671, 682, 683, 809, 1453, 1494, 2235, 2610, 2513, 2614, 2635, 2637, 2661.
Agrotis geniculata—2806.
Peridroma saucia—170, 300, 320, 323, 1454, 1464, 1492, 2164.
Pronoctua typica—1743, 2693.
Noctua baja—260, 323, 672.
Noctua rosaria—2158, 2169, 2191, 2198, 2200, 2224.
Noctua patefacta—2164.
Noctua sierræ—2164, 2169, 2191, 2224, 2661.
Noctua nigrum—565, 2169.
Noctua oblata—2168.
Noctua haruspica—688.
Noctua clandestina—96, 496, 555, 563, 2115.
Noctua havilæ—107, 555, 1216, 2168, 2224, 2684.
Noctua piscipellis—1377, 1743, 2685.
Noctua vocalis—2693, 2806.
Noctua atricincta—2552.
Chorizagrotis auxilaris—352, 355, 1002, 1120, 1126, 1142, 2107, 2110, 2682.
Chorizagrotis introferens—352, 563, 1120, 1126, 1142, 1183, 2171, 2610, 2689.
Chorizagrotis agrestis—53, 96, 103, 319, 323, 355, 435, 437, 1120, 1142, 1183, 1453, 2420, 2610, 2682, 2696, 2759, 2765.
Rhizagrotis albicosta—2252, 2647, 2659, 2662, 2663, 2670, 2676, 2679.
Rhizagrotis apicalis—2693.
Rhizagrotis lagena—538.
Feltia subgothica—225, 413, 1440, 1442, 2298, 2610, 2663, 2670, 2676, 2666, 2685, 2696.
Feltia venerabilis—435, 523, 536, 2487, 2527, 2480, 2751, 2759, 2763.
Porosagrotis muraenula—2135.
Porosagrotis catenula—1451, 1455, 1743, 2737, 2743, 2751, 2759.
Porosagrotis vetusta—2693, 2753, 2758, 2759, 2763.
Porosagrotis mimallonis—1743, 2693.
Porosagrotis rileyana—1973.
Porosagrotis orthogonia—120, 2337, 2763, 2336, 2758.
Porosagrotis pluralis—2610.
Porosagrotis dædalus—2526, 2806.
Carneades quadridentata—810, 891, 1419, 1453, 2748, 2753.
Carneades niveilinea—683, 688, 759, 1453, 2758.
Carneades oblongostigma—
Carneades ridingsiana—1744, 2748, 2164.
Carneades flavidens—1002, 1452, 1457, 2332, 2333, 2733, 2737, 2743, 2748, 2751, 2752.
Carneades flavicollis—681, 2610, 2612.
Carneades brocha—1743.
Carneades hollemani—1514.
Carneades misturata—1743.
Carneades mœrens—1743.
Carneades pleuritica—120, 2610, 2693.
Carneades rufula—2168, 2191, 2198, 2224, 2272.
Carneades friabilis—613.
Carneades detesta—1419.
Carneades cænis—1466, 2758.
Carneades medialis—891, 1494.
Carneades messoria—393, 809, 811, 1357, 1362, 1440, 1454, 1466, 1743, 2295, 2348, 2733, 2734, 2737.
Carneades lutulenta—1743.
Carneades lætificans—2693, 2333.

Family NOCTUIDAE.---(Continued.)

Carneades pedalis--2806.
Carneades infausta--2272.
Carneades munis--2806.
Carneades basiflava--2806.
Carneades insignata--1453, 1456, 1743, 2178, 2272, 2348, 2610, 2722, 2750, 2787, 2743, 2748, 2751, 2759, 2763.
Carneades lewisii--2806.
Carneades tessellata--381, 681, 683, 670, 689, 1655, 1657, 1673, 2347, 2348, 2485, 2621, 2651, 2652, 2634.
Carneades albipennis--800, 811, 1452, 1743, 2198, 2737, 2743, 2748, 2752, 2783.
Carneades pallipennis--451, 1437, 1440, 2332, 2610, 2613, 2614, 2637, 2659, 2663, 2664, 2737, 2743, 2748, 2750, 2751, 2752, 2758, 2763.
Carneades fusimacula--2586.
Carneades basalis--2235, 2298, 2613, 2614, 2621, 2625.
Carneades furtivus--2621.
Carneades servitus--2272.
Carneades obeliscoides--1743, 2235, 2651, 2748.
Carneades conjuncta--2737, 2743, 2759.
Carneades divergens--2168, 2169, 2198, 2224, 2235, 2689.
Carneades brunneigera--2693.
Carneades redimicula--1705, 2272, 2693.
Carneadea tesselloides--1437.
Carneadea silens--2134, 2272, 2610.
Richia aratrix--1743.
Richia parentalis--1002.
Richia decipiens--2693.
Agrotiphila colorado--1002.
Admetovis oxymorus--2806.
Mamestra imbrifera--688, 690, 2178, 2614.
Mamestra juncimacula--2693.
Mamestra lustralis--2806.
Mamestra discalis--2164.
Mamestra determinata--714, 2750.
Mamestra fusculenta--2471, 2476.
Mamestra farnhami--535.
Mamestra liquida--2806.
Mamestra atlantica --1126.
Mamestra candida--1743, 2295.
Mamestra subjuncta--671, 683, 689, 718, 2610.
Mamestra grandis--1118.
Mamestra invalida--2806.
Mamestra trifolii--431, 523, 569, 1705, 1714, 1803, 2103, 2106, 2109, 2110, 2171, 2178, 2198, 2235, 2298, 2610, 2689, 2710, 2730, 2734, 2731.
Mamestra oregonica--688.
Mamestra rosea--509, 555, 565.
Mamestra congermana--2552, 2610, 2651, 2654, 2663.
Mamestra picta--523, 535, 808, 1574, 2550, 2689.
Mamestra noverca--1126.
Mamestra renigera--125, 556, 628, 655, 688, 1236, 2633, 2648, 2719.
Mamestra olivacea 2131, 2164, 2178, 2709.
Mamestra lorea--601, 2133, 2164.
Mamestra vicina--131, 639, 672, 2128, 2150, 2285, 2576, 2578, 2610, 2614, 2693.
Scotogramma phoca--787.
Ulolonche orbiculata--538.
Ulolonche disticha--1889, 2215.
Ulolonche fasciata--493, 495.
Hadena niveivenosa--2691, 2699.
Hadena fractilinea--2715.
Hadena longula--1743, 2693.
Hadena passer--2105, 2621.
Hadena illata--103.
Hadena lateritia--535, 2164, 2682.
Hadena apamiformis--2806.
Hadena exornata--2274.
Hadena morna--790.
Hadena alticola--2689.
Hadena devastatrix--673, 682, 800, 2164, 2168.
Hadena arctia--1002, 2164.
Hadena occidens--2806.
Hadena lignicolor--673, 681, 685, 717, 2621, 2654, 2666.
Hadena inordinata--2806.
Hadena semilunata--535, 1180, 2133.
Hadena evelina--1467.
Hadena violacea--2806.
Hadena modica--800.
Hadena mactata--2164.
Hadena chryselectra--2693.
Hadena hulstii--2164.
Hadena plutonia--2164, 2178.
Hadena binotata--2298, 2693.
Hillia senescens--2806.
Pseudanarta flavidens--2806.
Pseudanarta flava--2806.
Pseudanarta singula--2806.
Oligia festivoides--564.
Perigea pulverulenta--1454, 2806.
Adita chionanthi--2806.
Homohadena figurata--2570.
Oncocnemis hayesi--2295.
Oncocnemis dayi--2271, 2272, 2806.
Oncocnemis fasciatus--2806.
Oncocnemis umbrifascia--690.
Oncocnemis levis--1743.
Oncocnemis augustus--1441, 1465, 1806, 1891, 2753.
Oncocnemis mirificalis--2295.
Oncocnemis iricolor--2806.
Oncocnemis extremis--2806.
Oncocnemis occata--523, 2753, 2963.
Oncocnemis chandleri--2693.
Oncocnemis colorado--2806.
Oncocnemis cibalis--1973.
Lathosea pullata--2806.
Polia ædon--2806.
Polia theodori--2806, 2693.
Laphygma frugiperda--1452, 1454.
Laphygma flavimaculata--2298.
Dargida (Eupsephopæctes) procinctus--
Nephelodes violans--2693.
Helotropha reniformis--2806.
Hydrœcia nictitans--683, 2552, 2621, 2663, 2679, 2689.
Hydrœcia limpida--671, 673.
Hydrœcia cerussata--2806.
Bellura (Arzama) obliquata--2523, 2587, 2806.
Leucania patricia--334.
Leucania alblilinea--488, 523, 2178, 2610.

Leucania phragmatidicola—685.
Leucania commoides—107, 2178.
Leucania unipuncta—1437, 2610, 2613.
Ufeus plicatus—320, 334, 741, 1495, 1743, 2612, 2622, 2642, 2643, 2645.
Ufeus unicolor—34, 2806.
Ufeus satyricus—2642.
Catabena (Adipsophanes) miscellus—111, 2110, 2126, 2147.
Crambodes talidiformis—536, 2471, 2563, 2567, 2752.
Caradrina civica—1743.
Caradrina extimia—523, 526, 555, 1632, 1633, 1634.
Prophila glabella—1362, 2203, 2333, 2748, 2752, 2758.
Himella thecata—527.
Himella contrahens—2603.
Orthodes crenulata (infirma)—682.
Orthodes cynica—80.
Tæniocampa curtica—1729, 1743, 2147, 2151, 2163, 2637, 2699, 2730.
Tæniocampa incincta—811.
Tæniocampa pacifica—31, 334, 1078.
Tæniocampa alia—320, 323, 325, 371.
Tæniocampa oviduca—1642, 2110, 2200, 2610, 2700, 2727.
Stretchia plusiiformis—301, 2610, 2613, 2614.
Stretchia variabilis—334.
Cosmia paleacea—2164.
Perigonica fulminans—2806.
Ipimorpha pleonectusa—326, 690, 756, 805.
Pyrrhia umbra—
Orthosia helva—2200.
Orthosia euroa—2693.
Scoliopteryx libatrix—555, 1002, 2128, 2695.
Litholomia napæa—334.
Xylina ferrealis—355.
Xylina bethunea—288, 360, 1464.
Xylina fagina—320, 323, 350.
Xylina georgii—1495.
Xylina carbonaria—334.
Xylomiges simplex (crucialis)—270.
Pleroma obliquata—2806.
Calocampa nupera—1464.
Calocampa cineritia—334, 350.
Cleophana antipoda—689.
Cucullia similaris—2806.
Cucullia asteroides—690, 1215, 2235, 2486.
Cucullia dorsalis—103.
Cucullia intermedia—539.
Cucullia cinderella—334.
Abrostola uretis—2653.
Deva palligera—2666.
Plusia æreoides—2621, 2676.
Plusia putnami—2806.
Plusia mappa—2806.
Plusia biloba—2552.
Plusia californica—638, 1002, 2118, 2168.
Plusia brassicæ—569, 690, 805, 776, 1002, 1716, 1726, 2610, 2637, 2763.
Plusia angulidens—2806.
Plusia epigæa—2806.
Plusia ampla—2806.
Plusia simplex—685, 690, 2550, 2578, 2610, 2613, 2756.
Plusia parilis—688.
Plusia snowii—2806.
Plusia russea—371, 2552, 2659.
Caloplusia hochenwarthi—2806.
Caloplusia divergens—2806.
Basilodes chrysopis—1714, 2235, 2298.
Stiria rugifrons—690, 2178, 2610, 2651, 2654, 2670, 2674.
Stibadium spumosum—689, 1714, 2200, 2699.
Plagiomimicus pitychromus—2203, 2652, 2670.
Plagiomimicus expallidus—2203.
Fala ptycophora—1714.
Acopa carina—1002, 1442.
Oxycnemis perfundis—565.
Nycterophæata luna—556, 565.
Copablepharon album—2806.
Copablepharon absidum—335, 336, 2235, 2298.
Thyreion rosea—556, 565.
Heliothis paradoxus—2048, 2077, 2118, 2178, 2235, 2298, 2614, 2670.
Heliothis armiger—807, 1806, 2252, 2298, 2763, 2764.
Heliothis dipsaceus—1002, 2091, 2203, 2219, 2235, 2252, 2298, 2708, 2709.
Heliothis scutosus—103, 530, 2153.
Heliothis suavis—623, 2163, 2471, 2526, 2573, 2696, 2708.
Heliothis phlogophagus—488, 505, 807, 1247, 1493, 2168, 2178, 2235.
Alaria gauræ—1906, 2203, 2652, 2615, 2663.
Alaria citronellus—689.
Rhododipsa volupia—2806.
Pseudacontia crustaria—2693.
Schinia cumatilis—1002, 2226, 2252, 2298, 2676, 2685, 2708, 2713, 2731, 2733, 2750, 2751, 2765.
Schinia trifascia—2252.
Schinia simplex—565.
Schinia acutilinea—2806.
Schinia brucei—2699.
Schinia separata—2252, 2806.
Schinia albafascia—2663, 2679, 2719, 2722, 2730, 2733.
Schinia jaguarina—107, 112, 115, 565, 685, 1002, 1236, 2162, 2252, 2610, 2689, 2709, 2722.
Schinia nobilis—2806.
Dasyspoudæa meadii—536, 555, 565, 2576, 2604, 2610.
Melaporphyria ononis—687, 2171.
Melicleptria græfiana—687, 2171.
Melicleptria pulchripennis—2806.
Melicleptria sueta—1514, 1733.
Heliolonche modicella—2806.
Heliaca nexilis—2565.
Anarta cordigera—2806.
Anarta quadrilunata—785.
Anarta melanopa—112, 334.
Anarta schœnherri—2806.
Acontia candefacta—602, 2096, 2143, 2151, 2526, 2573, 2634, 2654.
Acontia augustipennis—103, 112, 334.
Fruva obsoleta—360.
Xanthoptera semiflava—1732.
Lithacodia bellicula—602, 2610.
Erastria carneola—56, 107, 555, 559, 721.
Galgula partita (subpartita)—2048, 2077.
Drasteria erechta—334, 1733, 2227, 2252, 2610, 2734, 2737.
Euclidia cuspidea—566.

Family NOCTUIDAE.---(Continued.)

Synedoida inepta—1559.
Synedoida scrupulosa—1514.
Synedoida insperata—2806.
Syneda athabasca—1732, 2214.
Syneda adumbrata—541, 1531, 2565.
Syneda howlandii—523, 565, 2128, 2693.
Syneda perplexa—2806.
Syneda tejonica—2692.
Cirrhobolina deducta—1514.
Cirrhobolina mexicana—2693.
Catocala verrillana—2806.
Catocala relicta—2806.
Catocala pura—2666, 2700.
Catocala ultronia—800.
Catocala nebraskæ—2806.
Catocala californica—2730, 2734.
Catocala arizonæ—718.
Catocala aspasia—2806.
Catocala subnata—2090.
Toxocampa victoria—2806.
Phurys bistrigata—334.
Erebus odora—1311 1312, 1348.
Renugia latipes—2738.
Thysania zenobia—2806.
Homoptera calycanthata—2693.
Pheocyma lunifera—32, 103, 125.
Pseudaglossa lubricalis—119, 628, 1236, 2693.
Epizeuxis æmula—1348, 1440.
Philometra gaosalis (longilabris)—1730.
Philometra eumelusalis—602.
Bleptina caradrinalis—628.
Hypena humuli—282, 298, 334, 807, 1595, 2475

Family GEOMETRIDAE.

Tetracis grotearia—337.
Tetracis coloradia—730, 786, 1677.
Tetracis lorata—2686.
Metanema inatomaria—1002, 1181.
Ennomos magnarius—892, 2338, 2663, 2709, 2719, 2722, 2731, 2734, 2743.
Azelina hubnerata—428, 2693, 2694.
Endropia madusaria—655, 1732.
Endropia duaria—369.
Opistograptis baltearia—638.
Angerona crocataria—665, 134, 654, 689, 2694.
Synchlora excurvaria—103, 111, 536, 588, 2147, 2289.
Acidalia hepaticaria—1531.
Acidalia perirrorata—807.
Acidalia luteolata—687.
Acidalia ancellata—568, 623, 689, 1174, 2110, 2112, 2143, 2216.
Acidalia quinquilinearia—602, 1733, 2112.
Deilinia variolaria—2048
Corycia vestaliata—1174, 2112.
Eumacaria brunnearia—1174.
Semiothisa delectata—371, 488, 689, 690, 807, 1714.
Semiothisa respersata—307, 689, 2048.
Semiothisa californiata—523, 683, 689.
Phasiane meadiata—565, 690, 2135, 2178, 2573, 2586, 2610.
Phasiane mellistrigata—488, 2235, 2252.
Phasiane irrorata—1236.
Marmopteryx marmorata—1732, 1733, 2683, 2765.
Thamnonoma quadrilinearia—2765.
Thamnonoma quadraria—100, 785, 2138.
Thamnonoma wauaria—646.
Thamnonoma subcessaria—2048.
Thamnonoma sulphuraria—638, 1654, 1733, 2676, 2719, 2733, 2737, 2752.
Thamnonoma brunnearia—787.
Thamnonoma flavicaria—654.
Eufitchia ribearia—176.
Selidosema juturnaria—655.
Caripeta gertruda—2806.
Fidonia fimetaria—1114, 2091, 2096, 2112, 2693.
Hæmatopis grataria—56, 530, 635, 2147.
Caterva catenaria—832.
Euaspilates spinitaria—2604, 2666.
Gorytodes uncanaria—2110, 2112.
Biston ursarius—360.
Eubyia quernaria—1002, 2693.
Anisopteryx pometaria—218, 256.
Oporagena coloradensis—218, 1528.
Phibalapteryx intestinata—307, 2143.
Petrophora destinata—2143.
Petrophora montanata—2198, 2224.
Petrophora diversilineata—133, 1714.
Rheumaptera ruficillata—2806.
Hydriomane lustrata—269, 1114, 1531, 1559, 2078.

Family PYRAUSTIDAE.

Margaronia quadristigmalis—690, 2298.
Nomophila noctuella—119, 1225, 2178.
Metra ostreonalis—1744, 2178, 2200, 2610.
Pyrausta signatalis—112.
Pyrausta plumbosignalis—790, 1733, 2168, 2198, 2227.
Pyrausta unifacialis—687, 689, 1710, 2694.
Pyrausta fodinalis—986, 1709, 1710, 2143, 2196, 2216.
Loxostege sticticalis—555, 2147, 2178, 2471, 2480, 2487, 2666.
Loxostege obliteralis—2110, 2133, 2143, 2165, 2610.
Loxostege coloradensis—488, 536, 539, 565, 612, 654, 1225, 2203, 2235, 2603, 2604, 2610.
Loxostege lepidalis—54, 523, 2147, 2150
Loxostege cerealis—588, 1115, 1351, 1440, 1559, 2110, 2133, 2147, 2471, 2480, 2603.
Prorasea simalis—488, 523, 530, 536, 2178, 2692, 2708, 2731.
Titanio thalialis—56, 82, 112, 510, 516, 523, 530, 534, 535.
Scoparia centuriella—687.
Evergestis simulatilis—334, 431.
Chalcœla durifera—79, 82.
Schœnobius tripunctellus—125, 807.

Family PYRALIDIDAE.

Ugra griphalis—723, 1236, 2203.
Pyralis farinalis—91, 532.
Stericta breviornatalis—120, 588.

Family PHYCITIDAE.

Salebria delassalis—53.
Laodamia fusca—807, 1531, 1559, 2171, 2298.
Pyla scintillans—787.
Pima albiplagiatella—79, 539.
Etiella zinckenella—488, 523, 536, 539, 565.
Melitara dentata—74, 79, 2743, 2748, 2756, 2759.
Euzophera aglæella—21, 269, 1531, 2078.
Sarata perfuscalis—535, 556.
Heteroghraphis morrisonella—431, 2178.
Heteroghraphis albiella—689.
Honora oblitella—565, 1236, 2126, 2135, 2178.
Honora undulatella—544, 690, 2128, 2133.
Homœosoma impressale—107, 2127.
Homœosoma electellum—35, 103, 112, 2143, 2178.
Plodia interpunctella—828, 1449.
Peoria hæmatica—690.
Petaluma illibella—523, 654.

Family CRAMBIDAE.

Euchromius texanus—565, 689.
Crambus præfectellus—1002.
Crambus luteolellus—2135, 2148.
Crambus laqueatellus—2298.
Crambus innotatellus—689.
Crambus anceps—687, 689, 790.
Crambus teterrellus—807, 2198, 2221, 2227.
Crambus vulgivagellus—2198, 2298.
Crambus interminellus—2127.
Crambus caliginosellus—126, 235, 628, 2135.
Crambus mutabilis—107, 565, 623, 807, 2154.
Thaumatopsis repandus—635, 883, 892, 1236, 1463, 2200.
Thaumatopsis pexellus—690, 1714.
Thaumatopsis longipalpus—2048.

Family PTEROPHORIDAE.

Platyptilia carduidactyla—537, 1710, 2198, 2224.
Alucita monodactyla—685.
Oxyptilus periscelidactylus—2216.
Pterophorus lobidactylus—1973.

Family TORTRICIDAE.

Cacœcia rosaceana—120, 602.
Cacœcia zapulata—655.
Cacœcia argyrospila—716, 1258, 1906.
Cacœcia semiferana—123, 150, 1906.
Tortrix peritana—811.
Sciaphila osseana—2198, 2214.
Œnectra distincta—590, 672, 811.
Cenopis testulana—1907, 1908.

Family CONCHYLIDAE.

Idiographis ægrana—2168, 2224.

Family GRAPHOLITHIDAE.

Sericoris nubilana—103.
Sericoris puncticostana—
Pædisca circulana—599, 635, 2133, 2143.
Pædisca robinsonana—360.
Pædisca monogrammana—523, 2135.
Pædisca caniceps—628.
Pædisca agricolana—2133, 2148.
Pædisca cataclystina—602.
Pædisca matutina—565, 623, 628, 635.
Pædisca morrisoni—2135.
Pædisca albiguttana—2298.
Semasia striatana—2143.
Semasia taleana—2126.
Semasia ochreicostana—348.
Phoxopteris spiræifoliana—2143.
Phoxopteris spoliana—2091.
Carpocapsa pomonella—151, 311, 2252.

Family CHOREUTIDAE.

Choreutis onustana—785, 1117, 1531, 1557.
Choreutis diana—45, 60, 1531, 1559, 1606, 2078, 2091.
Acrolophus plumifrontellus—602.

Family TINEIDAE.

Tinea bisselliella—2071, 2205.

Family PRODOXIDAE.

Pronuba yuccasella—1231, 1219.
Porodoxus decipiens—537.

Family PLUTELLIDAE.

Plutella cruciferarum—45, 628.

Family GELECHIIDAE.

Psecadia discostrigella—785, 1531, 1117, 1537.
Depressaria nebulosa—29, 198, 623.
Depressaria posticella—690.
Depressaria umbraticostella—29.
Amydra effrenatella—29.

NOTES ON LEPIDOPTERA FROM THE ACCESSIONS CATALOGUE.

Cat. Nos.	*Dates of Captures*	*Collectors.*	*Localities.*	*Remarks.*
21	April 20	C. P. G.*	Fort Collins	Pupæ under stones.
29	April 25	C. P. G	Fort Collins	General collecting.
31	April 27	C. P. G	Fort Collins	Taken at light.
34	April 30	C. P. G	Fort Collins	Taken in office.
35	April 29	C. P. G	Fort Collins	General collecting.
37	May 3	C. P. G	Spring Canon†	General collecting.
45	May 11	C. P. G	Spring Canon	General collecting.
51	May 17	C. P. G	Fort Collins	General collecting
53	May 22	C. P. G	Fort Collins	General collecting.
54	May 23	C. P. G	Fort Collins	General collecting.
56	May 28	C. P. G	Fort Collins	Taken at light.
60	May 29	C. P. G	Rist Canon‡	In the foothills.
74	June 7	C. P. G	Fort Collins	Taken at light.
79	June 10	C. P. G	Fort Collins	Taken at light.
80	June 10	C. P. G	Fort Collins	About willows, pairing.
82	June 11	C. P. G	Fort Collins	Taken at light.
85	June 14	C. P. G	Fort Collins	Flying about currant bushes.
86	June 15	C. P. G	Fort Collins	General collecting.
91	June 17	C. P. G	Fort Collins	Taken at light.
96	June 21	G. H. B.§	Fort Collins	Taken at light.
100	June 22	G. H. B	Fort Collins	About currant and gooseberry bushes.
101	June 23	C. P. G	Fort Collins	General collecting.
103	June 22	C. P. G	Fort Collins	At light in laboratory.
107	June 23	G. H. B	Fort Collins	At light in laboratory.
111	June 24	G. H. B	Fort Collins	At light in laboratory.
112	June 25	G. H. B	Fort Collins	At light in laboratory.
115	June 27	C. P. G	Fort Collins	At light in laboratory.
118	June 20	C. P. G	Fort Collins	Larvæ from apple tree, May 19.
119	June 29	G. H. B	Fort Collins	At light in laboratory.
120	June 30	G. H. B	Fort Collins	At light in laboratory.
123	July 6	G. H. B	Fort Collins	Larvæ from box elder, June 19.
125	July 2	C. P. G	Fort Collins	At light in laboratory.
126	July 6	C. P. G	Fort Collins	At light in laboratory.
131	July 8	C. P. G	Fort Collins	
133	July 12	C. P. G	Fort Collins	
134	July 14	G. H. B	Fort Collins	From larvæ found on currant, in June.
150	Aug. 17	G. H. B	Fort Collins	At light.
151	Aug. 29	G. H. B	Fort Collins	From apples in orchard.
170	Oct. 15	C. P. G	Fort Collins	Taken at light.
198	Mar. 11	C. F. B.‖	Fort Collins	Flying about lamp.
209	Mar. 24	C. F. B	Fort Collins	From larvæ under stones, March 24.

* C. P. Gillette.
† In the foothills, seven to eight miles southwest of Fort Collins.
‡ In the foothills, eight to twelve miles northwest of Fort Collins.
§ G. H. Buffum.
‖ C. F. Baker.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
223	Mar. 27	C. P. G.	Fort Collins	Larvæ under boards and stones.
235	Mar. 31	C. P. G.	Fort Collins	In greenhouse.
245	April 9	C. P. G.	Rist Canon	Under stones.
254	April 12	C. P. G.	Spring Canon	From pupæ.
256	April 14	C. F. B.	Spring Canon	At sugar.
260	April 16	C. P. G.	Spring Canon	About light.
269	April 16	C. P. G.	Rist Canon	Taken flying.
270	April 17	C. F. B.	Fort Collins	About light.
280	April 18	C. P. G.	Fort Collins	From pupæ under stones, April 9.
282	April 18	C. P. G.	Fort Collins	On outside of window.
288	April 22	C. F. B.	Fort Collins	Taken on window.
298	April 19	C. P. G.	Fort Collins	On wing.
300	April 24	C. P. G.	Fort Collins	At sugar.
301	April 25	C. P. G.	Fort Collins	About light.
302	April 25	C. P. G.	Fort Collins	From larvæ taken under stone, April 8.
319	April 28	C. P. G.	Fort Collins	At light.
320	April 28	C. F. B.	Fort Collins	At sugar.
323	April 29	C. F. B.	Fort Collins	At sugar.
325	April 30	C. S. C.*	Fort Collins	From cocoons.
326	April 30	C. P. G.	Fort Collins	Larvæ from cottonwood, June 29.
334	April 30	C. P. G.	Denver	About light.
337	April 26	C. F. B.	Denver	Larvæ taken under boards.
348	May 3	C. F. B.	Denver	Taken on box elder.
350	April 30	C. F. B.	Denver	At sugar.
351	April 30	C. F. B.	Denver	From larvæ on Virginia creeper, July.
352	May 2	C. F. B.	Denver	At light.
355	May 6	C. F. B.	Denver	At sugar.
360	May 7	C. P. G.	Larimer County	General collecting.
369	May 9	C. F. B.	Fort Collins	Larvæ taken in winter.
371	May 9	C. F. B.	Denver	About light.
381	May 12	C. F. B.	Fort Collins	About light.
388	May 14	C. P. G.	Trinidad	Under stones.
393	May 14	C. F. B.	Fort Collins	General collecting in foothills.
401	May 17	C. P. G.	Fort Collins	From larvæ on four-o'clock, Aug. 14
413	May 18	C. P. G.	Fort Collins	From alfalfa.
420	May 9	C. P. G.	Fort Collins	From larvæ under boards, April 12.
424	May 21	C. F. B.	Horsetooth Gulch†	General collecting.
428	May 23	C. P. G.	Horsetooth Gulch	General collecting.
431	May 14	C. P. G.	Pueblo	At light.
433	May 7	C. P. G.	Fort Collins	From pupæ under boards, March 3.
434	May 7	C. P. G.	Fort Collins	From larvæ under boards, March 26.
435	May 14	C. P. G.	Denver	At light.
436	May 14	C. P. G.	Fort Collins	Larvæ from Virginia creeper, July 23.
437	May 14	C. P. G.	Denver	From larvæ under boards. March 26.
441	May 20	C. P. G.	Denver	From pupæ dug from ground.
451	May 26	C. P. G.	Manitou	From rose galls, May 8.
467	May 28	C. F. B.	Rist Canon	Taken in general collecting.
478	May 31	C. P. G.	Fort Collins	From larvæ under boards, April 12.
488	June 5	C. P. G.	Denver	At light.
492	May 19	C. P. G.	Soldier Cañon‡	On wing.
493	May 21	C. P. G.	Fort Collins	From larvæ under boards, April 12. Fed on alfalfa.
494	May 21	C. P. G.	Rist Canon	From larvæ under stones. Fed on grass.
495	May 22	C. P. G.	Fort Collins	From larvæ under boards, April 12. Fed alfalfa.
496	May 24	C. P. G.	Rist Canon	Larvæ under stones, April 16.
508	June 8	C. P. G.	Trinidad	Taken under bark of cottonwood, May 14.
509	June 6	C. S. C.	Fort Collins	From seed pods of *Glycyrrhiza lepidota*.
510	June 10	C. P. G.	Fort Collins	Swept from beans.

* Prof. C. S. Crandall.
† Foothills, about eight miles southwest of Fort Collins.
‡ Foothills, about five miles west of Fort Collins.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
516	June 13	C. F. B	Trinidad	Sweeping grass along river.
523	June 4	C. P. G	Denver	At light.
526	June 4	C. P. G	Fort Collins	From larvæ under boards, May 3. Fed clover.
527	June 4	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed clover.
530	June 19	C. F. B	Fort Collins	At light.
532	June 19	R. C. S.*	Fort Collins	In a barn stored with alfalfa.
534	June 18	C. P. G	Fort Collins	Larvæ in stems of currant in spring.
535	June 21	C. F. B	Fort Collins	At light
536	June 22	C. F. B	Fort Collins	At light.
537	June 16	C. P. G	Dolores	General collecting.
538	June 13	C. P. G	Pueblo	At light.
539	June 12	C. P. G	Denver	At light.
541	June 15	C. P. G	Dolores	General collecting.
544	June 17	C. P. G	Dolores	General collecting.
547	June 20	C. P. G	Hermosa	General collecting.
548	June 20	C. P. G	Silverton	General collecting.
554	June 25	C. F. B	Fort Collins	At light.
555	June 13	C. F. B	Fort Collins	At light.
556	June 20	C. F. B	Fort Collins	At light.
559	June 13	C. F. B	Fort Collins	Taken flying.
560	June 10	C. F. B	Fort Collins	From larvæ under boards, April 22. Fed clover.
562	June 1	C. F. B	Fort Collins	General collecting.
563	June 10	C. F. B	Fort Collins	At light.
564	June 25	C. F. B	Manitou	General collecting.
565	June 25	C. F. B	Denver	At light.
566	June 24	C. F. B	Montrose	General collecting.
567	June 22	C. F. B	Ouray	General collecting.
568	June 25	C. P. G	Colorado Springs	At light
569	June 25	C. F. B	Fort Collins	At light.
581	June 30	C. P. G	Spring Canon	General collecting.
587	June 30	C. P. G	Spring Canon	On willow.
588	June 29	C. P. G	Fort Collins	At light.
590	July 2	C. F. B	Fort Collins	General collecting.
599	July 2	C. P. G	Fort Collins	General collecting.
601	July 3	C. P. G	Fort Collins	At light.
602	July 4	C. P. G	Fort Collins	From larvæ on raspberry, June 29.
613	July 5	C. F. B	Horsetooth Gulch	From larvæ on *Senecio*, May 21. Fed clover.
623	June 5	C. P. G	Fort Collins	At light.
627	June 23	C. F. B	Fort Collins	From larvæ under boards, April 22. Fed clover.
628	June 7	C. P. G	Fort Collins	At light.
629	July 6	C. P. G	Fort Collins	At light.
635	July 9	C. P. G	Fort Collins	At light.
636	July 7	C. P. G	Fort Collins	At light.
637	July 11	R. C. S	Fort Collins	
638	July 12	C. P. G	Spring Canon	General collecting.
639	July 12	C. P. G	Spring Canon	On thistle blossom.
646	July 12	C. P. G	Ouray	From larvæ on *Ribes hudsonianus* and *R. floridanus*.
652	July 13	C. F. B	Rist Canon	From larvæ on rose, May 28. Fed clover.
654	July 14	C. P. G	Fort Collins	At light.
655	July 14	C. P. G	Rist Canon	General collecting.
659	July 8	C. P. G	Fort Collins	Reared from pupæ.
665	July 9	C. F. B	Larimer County	General collecting in foothills.
671	July 16	C. F. B	Fort Collins	At sugar.
672	July 17	C. F. B	Fort Collins	At sugar.

* Ross C. Stephenson.

Cat. Nos.	Dates of Captures.	Collectors.	Location.	Remarks.
673	July 18	C. F. B	Fort Collins	At sugar.
674	July 17	C. F. B	Fort Collins	General collecting.
681	July 19	C. F. B	Fort Collins	At sugar.
682	July 20	R. C. S	Fort Collins	At sugar.
683	July 21	C. F. B	Fort Collins	At sugar.
684	July 19	C. P. G	Georgetown	General collecting.
685	July 20	C. P. G	Denver	Taken at light.
686	July 21	C. P. G	Denver	General collecting.
687	July 15	C. P. G	Graymont	General collecting. About 9,000 feet altitude.
688	July 22	C. P. G	Fort Collins	At light.
689	July 14	C. P. G	Denver	At light.
690	July 25	C. P. G	Denver	At light.
691	July 23	C. P. G	Fort Collins	General collecting.
693	July 24	C. P. G	Georgetown	Cocoons abundant on aspen.
695	July 19	C. P. G	Spring Canon	From larvæ on *Iva*, June 30.
699	July 19	C. P. G	Fort Collins	From larvæ rolling cottonwood leaves, June 29.
705	July 20	C. P. G	Trinidad	From larvæ under stones, May 14. Fed clover.
713	July 25	C. P. G	Fort Collins	From larvæ on *Symphoricarpos occidentalis*, July 8.
714	July 5	C. P. G	Fort Collins	From larvæ under boards, April 12. Fed clover.
715	July 4	C. P. G	Ouray	From larvæ on *Ribes hudsonianus* and *R. floridanus*, June 23.
716	July 5	C. P. G	Fort Collins	Bred from pupæ on walnut, June 29.
717	July 20	C. F. B	Fort Collins	From larvæ under boards, May 8. Fed clover.
718	July 23	C. P. G	Fort Collins	At light.
719	July 5	C. P. G	Fort Collins	From larvæ on willow, June 6.
720	July 6	C. F. B	Fort Collins	General collecting.
721	July 20	C. F. B	Fort Collins	General collecting.
723	June 27	C. P. G	Fort Collins	From larvæ under boards, April 27 Fed clover.
726	July 15	C. P. G	Graymont	Altitude, 12,000 feet.
729	July 15	C. P. G	Graymont	Altitude, 12,500 feet.
730	July 15	C. P. G	Graymont	Taken 9,500 to 12 000 feet altitude.
732	July 15	C. P. G	Graymont	Altitude, 12,500 feet to summit of Gray's Peak.
735	July 15	C. P. G	Graymont	Altitude, 11,000 to 12,000 feet.
738	July 19	C. P. G	Graymont	Altitude, 9,500 to 10,000 feet.
739	July 19	C. P. G	Georgetown	Altitude, 8,600 feet.
740	July 18	C. P. G	Fort Collins	General collecting.
741	Aug. 5	C. F. B	Fort Collins	General collecting
747	Aug. 4	C. F. B	Fort Collins	From pupæ on cabbage.
756	July 29	C. P. G	Fort Collins	From larvæ on cottonwood.
757	Aug. 5	C. P. G	Graymont	From larvæ taken on yarrow, July 18.
759	Aug. 1	C. P. G	Fort Collins	From pupæ on cabbage, July.
776	Aug. 8	C. F. B	Fort Collins	Larvæ taken on cabbage, July.
778	Aug. 11	C. F. B	Fort Collins	General collecting.
780	Aug. 11	C. P. G	Rustic	General collecting.
781	Aug. 11	C. P. G	Beaver Creek	General collecting.
783	Aug 11	C. P. G	Owl Canon*	General collecting.
785	Aug. 1	C. P. G	Beaver Creek	General collecting; 10,000 to 12,000 feet altitude.
786	July 30	C. P. G	Stove Prairie†	General collecting.
787	Aug. 4	C. P. G	Cameron Pass	Between Big South and Clark's ranch.
788	Aug. 8	C. P. G	Long Gulch	Near Stove Prairie.
789	July 30	C. P. G	Rist Canon	General collecting

* Foothills, twenty miles northwest of Fort Collins.
† In foothills, sixteen miles west of Fort Collins.

Cat. Nos.	Dates of Captures.	Collectors.	Location.	Remarks.
790	July 31	C. P. G.	Little South	General collecting in foothills.
791	Aug. 2	C. P. G.	Hourglass Lake	Near timber line.
792	Aug. 3	C. P. G.	Larimer County	Above and near timber line.
793	Aug. 7	C. P. G.	Larimer County	General collecting.
795	July 30	C P. G.	Rist Canon	General collecting.
800	Aug. 18	C. P. G.	Fort Collins	At sugar.
805	Aug. 10	R. C. S.	Denver	General collecting.
807	Aug. 25	C. P. G.	Denver	At light.
808	Aug. 25	C. F. B.	Fort Collins	General collecting.
809	Aug. 19	C. P. G.	Fort Collins	At sugar.
810	Aug. 19	C. P. G.	Fort Collins	At light.
811	Aug. 26	C. P. G.	Fort Collins	At sugar.
813	Aug. 19	C. P. G.	Fort Collins	On side of house.
818	Aug. 27	C. P. G.	Fort Collins	Miscellaneous collecting.
823	Sept. 21	C. F. B.	Boulder	General collecting.
828	Sept. 21	C. P. G.	Fort Collins	Larvæ in oatmeal.
830	Sept. 10	C. F. B.	Fort Collins	About flowers in evening.
883	Oct. 8	C. F. B.	Larimer County	Taken on shore of a lake.
891	Sept. 20	C. P. G.	Denver	At light.
892	Sept. 30	C. P. G.	Manitou	General collecting.
893	Aug. 1	C. F. B.	Larimer County	General collecting in foothills.
986	Feb. 22	C. F. B.	Fort Collins	From pupæ of *Philampelus achemon.*
1001	Feb. 27	C. F. B.	Fort Collins	Larvæ from stems of *Œnothera biennis.*
1002	———	P. S.*	Larimer County	
1078	April 7	C. P. G.	Fort Collins	Larvæ taken on steps.
1114	May 12	C. P. G.	Fort Collins	General collecting in foothills.
1115	May 13	C. F. B.	Fort Collins	General collecting along river.
1117	May 12	C. P. G.	Fort Collins	From flowers in foothills.
1118	May 12	C. P. G.	Fort Collins	Abundant on *Pinus ponderosa, var. scopulorum.*
1120	May 15	C. P. G.	Fort Collins	From flowers in foothills.
1126	May 22	C. P. G.	Fort Collins	Flying about laboratory.
1127	May 10	C. F. B.	Fort Collins	Larvæ on apple tree, Sept. 17.
1142	May 26	C. P. G.	Fort Collins	Flying about laboratory.
1145	June 5	C. P. G.	Horsetooth Gulch	General collecting.
1153	June 5	P. K. B.†	Fort Collins	General collecting.
1159	June 9	R. C. S.	Fort Collins	Sweeping a cruciferous plant.
1165	June 11	C. P. G.	Fort Collins	General collecting.
1166	June 11	C. P. G.	Fort Collins	General collecting.
1174	June 14	C. P. G.	Soldier Canon	Flying in sunshine.
1180	June 12	C. P. G.	Fort Collins	At light.
1181	June 7	R. A. M.‡	Fort Collins	At light.
1183	June 4	C. P. G.	Fort Collins	On window.
1215	June 20	C. F. B.	Fort Collins	From larvæ on *Solidago*, July 20.
1216	June 17	C. P. G.	Fort Collins	On laboratory window.
1217	June 17	C. P. G.	Fort Collins	On flowers of *Astragalus bisulcatus.*
1219	June 2	C. P. G.	Fort Collins	From larvæ in yucca stems during winter.
1220	June 9	C. P. G.	Fort Collins	From larvæ in currant stems.
1225	July 4	C. P. G.	Fort Collins	General collecting.
1226	June 28	C. F. B.	Fort Collins	From eggs deposited by moth.
1231	July 1	C. P. G.	Fort Collins	From larvæ in yucca stems.
1236	July 7	C. F. B.	Fort Collins	Flying about lamp.
1246	July 10	C. F. B.	Horsetooth Gulch	From caterpillar, taken June 30.
1247	July 10	C. F. B.	Fort Collins	Larvæ on *Ellisia nyctelea*, June 21.
1257	June 30	C. F. B.	Fort Collins	From larvæ on *Ellisia nyctelea.*
1258	June 30	C. F. B.	Fort Collins	Larvæ on apple in June.
1259	June 29	C. F. B.	Fort Collins	From larvæ on nettle, June 24.
1261	June 30	H. S. K.§	Fort Collins	From larvæ on *Rumex*, June 1.

* Paul Schlarbaum.
† P. K. Blinn.
‡ R. A. Maxfield.
§ H. S. Kendall.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
1311	June 29	C. P. G	Fort Collins	At sugar.
1312	June 29	C. P. G	Fort Collins	At light.
1348	July 15	R. C. S	Fort Collins	At light.
1351	July 12	C. F. B	Fort Collins	Larvæ on garden weed in June.
1357	Aug. 8	C. F. B	Fort Collins	Bred from larvæ in ground about *Ellisia nyctelea*, June 21.
1362	Aug. 2	C. F. B	Fort Collins	At light.
1365	Aug. 10	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1368	Aug. 10	E. D. V *	Estes Park	General collecting.
1374	Aug. 17	C. F B	Fort Collins	From larvæ on fennel, July 25.
1375	Aug. 24	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1376	Aug. 14	C. F. B	Fort Collins	From larvæ on fennel, July 25.
1377	Aug. 13	C. F. B	Fort Collins	At light.
1402	Aug. –	P. K. B	Berthoud	General collecting.
1419	Sept. 13	H. S. K	Fort Collins	At light.
1426	Sept. 3	C. P. G	Fort Collins	Larvæ on hollyhock, August 26.
1432	Sept. 13	C. F. B	Fort Collins	From larvæ on fennel, June 25.
1437	Sept. 9	C. P. G	Fort Collins	At light and sugar.
1440	Sept. 7	C. P. G	Fort Collins	At light.
1441	Sept. 14	C. P. G	Fort Collins	At light.
1442	Sept. 13	H. S. K	Fort Collins	At light.
1448	Sept. 10	C. F. B	Fort Collins	From larvæ on fennel, June 25.
1449	Sept. 19	C. P. G	Fort Collins	Larvæ in old honey comb, Sept. 14.
1451	Sept. 18	H. S K	Fort Collins	At light.
1452	Sept. 18	H. S. K	Fort Collins	At sugar.
1453	Sept. 25	C. P. G	Fort Collins	About laboratory windows.
1454	Sept. 28	C. P. G	Fort Collins	About laboratory windows.
1455	Sept. 29	C. P. G	Fort Collins	About laboratory windows.
1456	Sept. 25	H. S. K	Fort Collins	At sugar.
1457	Sept. 21	H. S. K	Fort Collins	At sugar.
1463	Oct. 4	C. P. G	Fort Collins	About windows.
1464	Oct. 8	C. P. G	Fort Collins	About windows.
1465	Oct. 9	C. P. G	Fort Collins	About windows.
1466	Oct. 12	H. S. K	Fort Collins	At sugar.
1467	Oct. 12	H. S. K	Fort Collins	At sugar.
1492	1893	———	Fort Collins	From larvæ on *Petunia*, Aug. 24.
1493	1893	———	Fort Collins	From larvæ in flowers of *Grindelia squarosa*, Sept. 1.
1494	Oct. 23	H. S. K	Fort Collins	At sugar.
1495	Nov. 3	H. S. K	Fort Collins	At sugar.
1514	1893	P. S	Loveland	Miscellaneous collecting.
1528	April 9	C. P. G	Fort Collins	From box elder tree.
1531	April 10	C. P. G	Rist Canon	Miscellaneous collecting.
1557	April 20	C. F. B	Rist Canon	Taken on wing.
1559	April 21	C. P. G	Horsetooth Gulch	Miscellaneous collecting.
1574	April 23	C. F. B	Fort Collins	From pupæ taken under stone, March 20.
1575	April 23	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1576	April 25	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1577	April 26	C. F. B	Fort Collins	From larvæ on walnut, April 9.
1595	May 14	H. S. K	Fort Collins	At light.
1606	May 7	C. F. B	Dixon Canon	
1632	June 3	C. F. B	Fort Collins	Larvæ under boards, May 20. Fed alfalfa.
1633	June 7	C. F. B	Fort Collins	Larvæ under boards, May 30. Fed alfalfa.
1634	June 12	C. F. B	Fort Collins	Larvæ under boards, May 20. Fed alfalfa.
1642	May 24	C. P. G	Fort Collins	At light.
1649	May 12	C. P. G	Pleasant Valley	On thistle bloom.
1654	May 30	C. P. G	Fort Collins	General collecting.
1655	July —	C. P. G	Fort Collins	From larvæ about *Rumex*, May 30.
1657	July —	C. F. B	Fort Collins	From larvæ about *Rumex*, May 30.
1659	July —	C. F. B	Fort Collins	Larvæ on *Oxybaphus hursutus*, July 12.
1673	July —	C. P. G	Fort Collins	From larvæ about cabbage, July 12.

* E. D. Varney.

Cat. Nos.	*Dates of Captures.*	*Collectors.*	*Localities.*	*Remarks.*
1677	July 19	C. P. G	Estes Park	General collecting.
1700	July 7	C. F. B	Cameron Pass	General collecting.
1704	July 12	C. F. B	Steamboat Springs	General collecting.
1705	Aug. 8	C. P. G	Colorado Springs	General collecting.
1706	July 5	C F. B	Cameron Pass	General collecting above timber line.
1709	July 9	C. F. B	Estes Park	General collecting.
1710	July 11	C. F. B	Estes Park	General collecting.
1714	Aug. 3	C. F. B	Colorado Springs	At light.
1715	Aug. 6	C. F. B	Fort Collins	Bred from larvæ on cabbage, Aug. 4.
1716	Aug. 4	C. P. G	Colorado Springs	From pupæ on poplar, Aug. 1.
1726	Aug. 23	C. F. B	Colorado Springs	From larvæ on cabbage, Aug. 4.
1729	Aug. 10	C. F. B	Fort Collins	At sugar.
1730	Aug. 1	C. F. B	Fort Collins	General collecting.
1732	July 10	C. P. G	Estes Park	Miscellaneous collecting, altitude 9,000 ft.
1733	July 12	C. P. G	Estes Park	Miscellaneous collecting.
1734	July 16	C. P. G	Estes Park	Miscellaneous collecting.
1743	Aug. 23	C. P. G	Glenwood Springs	At light.
1744	Aug. 23	C. P. G	Leadville	Miscellaneous collecting.
1803	July 28	C. P. G	Cripple Creek	At light.
1804	July 20	C. P. G	Near Lyons	General collecting.
1805	Sept. 14	C. P. G	Long's Peak	Above timber; altitude 12,000 feet.
1806	Sept. 30	C. P. G	Denver	At light.
1889	June 15	C. P. G	Horsetooth Gulch	General collecting.
1891	June 19	C. P. G	Fort Collins	On apple.
1900	May 1	C. P. G	Fort Collins	From cocoons on rose, April 25.
1906	June 24	C. P. G	Fort Collins	Moths reared from apple and box elder.
1907	July 1	C. P. G	Spring Canon	Reared from choke cherry.
1908	June 28	C. P. G	Spring Canon	Reared from cherry.
1918	July 10	C. P. G	Fort Collins	Cottonwood leaf roller.
1922	July 10	P. S	Loveland	General collecting.
1950	June 18	C. P. G	Fort Collins	From cottonwood leaves in spring.
1959	Sept. 8	C. P. G	Fort Collins	General collecting.
1973	Sept. 25	C. P. G	Denver	At light.
2071	April 19	C. P. G	Fort Collins	Taken on inside of window.
2078	April 29	C. P. G	Dixon Canon	General collecting.
2090	May 4	C. P. G	Fort Collins	On *Amelinchier alnifolia.*
2091	May 4	C. P. G	Fort Collins	Miscellaneous sweeping.
2096	May 9	C. P. G	Dixon Canon	
2101	May 12	J. D. S.*	Fort Collins	Resting on ground.
2103	May 13	Mrs. J. D. S.	Fort Collins	At light in room.
2105	April 28	C. S.†	Fort Collins	Miscellaneous collecting.
2106	May 20	C. P. G	Fort Collins	In lantern trap.
2107	May 19	C. P. G	Fort Collins	On laboratory windows.
2109	May 21	C. P. G	Fort Collins	In lantern trap.
2110	May 22	C. P. G	Fort Collins	In lantern trap.
2112	May 23	C. P. G	Boulder	In canon near town.
2113	May 27	C. P. G	Fort Collins	In lantern trap.
2115	May 28	C. P. G	Fort Collins	Taken on window.
2116	May 28	C. P. G	Laporte	Taken on ground.
2118	May 29	C. P. G	Fort Collins	Taken about lights.
2123	June 2	C. P. G	Fort Collins	Taken pairing on grass.
2126	June 4	C. P. G	Fort Collins	In lantern trap.
2127	June 7	C. P. G	Fort Collins	In lantern trap.
2128	June 8	C. P. G	Fort Collins	In lantern trap.
2131	June 9	C. P. G	Fort Collins	At sugar.
2133	June 9	C. P. G	Fort Collins	In lantern trap.
2134	June 10	C. P. G	Fort Collins	In lantern trap.
2135	June 11	C. P. G	Fort Collins	In lantern trap.
2138	June 15	C. P. G	Foothills	Near Fort Collins.
2143	June 15	C. P. G	Laporte	Larimer county.

* J. D. Stannard.
† Carlos Stannard.

Cat. Nos.	Dates of Captures	Collectors.	Localities.	Remarks.
2147	June 15	C. P. G	Laporte	In lantern trap.
2148	June 16	C. P. G	Laporte	In lantern trap.
2149	June 15	C. P. G	Foothills	On alfalfa bloom.
2150	June 17	C. P G	Foothills	In lantern trap.
2151	June 2	C. P. G	Foothills	In lantern trap.
2153	June 13	C. P. G	Larimer County	On bloom of *Erigeron*, sp.
2154	June 26	C. P. G	Fort Collins	At light
2159	June 25	C. P. G	Laporte	On bloom of thistle.
2162	June 29	C. P. G	Fort Collins	In lantern trap.
2163	June 27	C. P. G	Fort Collins	In lantern trap.
2164	July 9	C. P. G	Foothills	Twelve miles west of Fort Collins.
2168	July 3	C. P. G	Foothills	Little Beaver Creek 9,000 feet altitude.
2171	July 4	C. P. G	Larimer County	Taken above timber line.
2178	July 16	C. P. G	Denver	At electric light.
2179	July 15	W. T. P *	Estes Park	General collecting.
2191	July 6	J. H. C.†	Larimer County	Little Beaver Creek, 9,000 feet altitude.
2195	July 4	C. P. G	Larimer County	Between Little Beaver and timber line.
2196	July 18	C. P. G	Golden	Butterflies, mostly on *Clematis ligustici-folia*.
2198	July 3	C. P. G	Golden	In lantern trap. 9,000 feet a'titude.
2200	July 28	C. P. G	Fort Collins	In lantern trap.
2203	July 28	C. P. G	Fort Collins	In lantern trap.
2204	July 4	C. P. G	Larimer County	Taken above timber, Little Beaver Creek.
2205	July 31	J. H. C	Fort Collins	Larvæ eating saddle blanket.
2206	July 30	E. D. V	Fort Collins	General collecting.
2207	Aug. 2	C. P. G	Fort Collins	On flowers of *Mentha canadensis*.
2212	July 13	C. F. B	Fort Collins	General collecting.
2214	July 1	C P. G	Larimer County	Rist Canon.
2215	June 14	C. P. G	Larimer County	Taken at 7,000 feet altitude, in evening on flowers on *Jamesii americana*.
2216	June 14	C. P. G	Foothills	Ten miles northwest of Fort Collins.
2219	Aug. 5	C. P. G	Fort Collins	At light.
2221	Aug. 6	E. D. V	Fort Collins	Taken along river.
2224	July 6	C. P. G	Larimer County	In lantern trap, 9,000 feet altitude.
2225	July 20	J. H C	Fort Collins	
2226	Aug. 7	C. P. G	Fort Collins	In lantern trap.
2227	July 18	C. P. G	Larimer County	Taken between 8,000 and 9,000 feet altitude.
2235	Aug. 11	C. P. G	Denver	At light.
2248	Aug. 12	C. P. G	Palmer Lake	Taken in canon.
2250	Aug. 12	C. P. G	Palmer Lake	On little oaks in canon.
2252	Aug. 13	C. P. G	Denver	At light.
2258	Aug. 24	C. P. G	Canon City	
2271	Aug. 23	C. P. G	Mt. Ouray	Between 10,500 and 11,500 feet altitude.
2272	Aug. 23	C. P. G	Marshall Pass	On bloom of *Senecio* sp. 10,000 feet altitude.
2274	Aug. 23	C. P. G	Marshall Pass	On bloom of *Senecio* sp. 10,000 feet altitude.
2285	Aug. 22	C. P. G	Cimarron	Abundant on *Alnus viridis*.
2288	Aug. 21	C. P. G	Cerro Summit	On *Sarcobatus vermiculatus*.
2289	Aug. 21	C. P. G	Cerro Summit	At about 8,000 feet altitude.
2293	Aug. 16	C. P. G	Marshall Pass	Sweeping willow.
2294	Aug. 22	C. P. G	Cimarron	General collecting, 7,000 feet altitude.
2295	Aug. 22	C. P. G	Cimarron	Between Cimarron and Cerro Summit.
2298	Aug. 16	C. P. G	Denver	Taken at light.
2332	Sept 30	C. P. G	Fort Collins	Taken at light.
2333	Oct. 2	C. P. G	Fort Collins	At light.
2336	Oct. 5	C. P. G	Fort Collins	At light.
2337	Oct. 7	C. P. G	Fort Collins	At light.
2338	Oct. 5	E. G. T	Fort Collins	Taken at light.

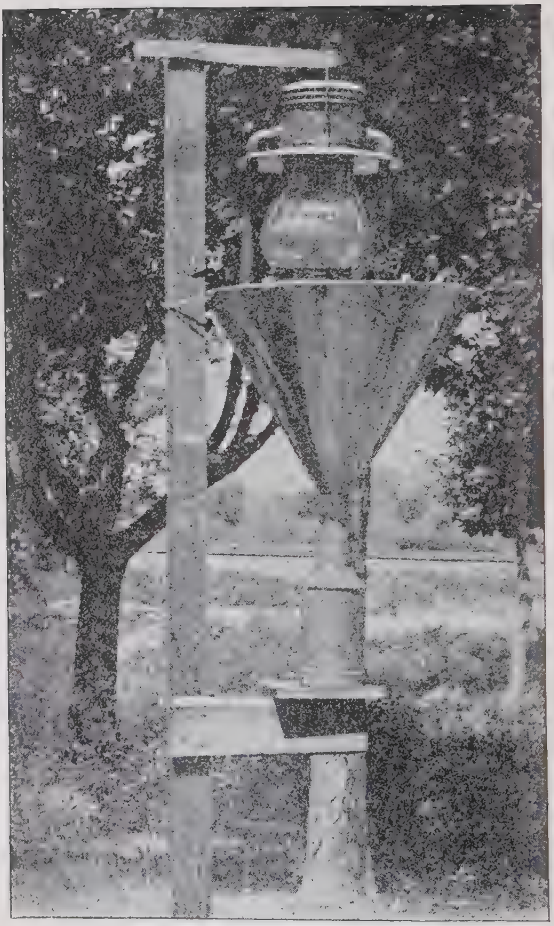
* W. T. Park.
† J. H. Cowen.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
2347	May 21	C. P. G	Fort Collins	About tomatoes.
2348	Nov. 1	C. P. G	Fort Collins	Larvæ taken June 2-5.
2423	April 28	C. P. G	Delta	Cocoon taken from plum.
2462	May 17	E. A. G.*	Fort Collins	Taken on lawn.
2463	June 16	E. A. G	Belivue	General collecting.
2465	May 15	C. P. G	Near Fort Collins	Miscellaneous collecting.
2469	May 17	C. P. G	Fort Collins	Taken on window
2471	June 18	C. P. G	Fort Collins	In lantern trap.
2473	May 20	E. A. G	Fort Collins	Taken on window.
2475	June 19	C. P. G	Fort Collins	At light.
2476	June 21	E. A. G	Fort Collins	At light, one female full of eggs.
2480	May 20	C. P. G	Fort Collins	In lantern trap.
2486	May 22	C. P. G	Denver	At electric light.
2487	May 23	C. P. G	Fort Collins	At light.
2499	May 23	E. G. T	Fort Collins	Larvæ taken May 3. Fed on alfalfa and box elder.
2508	May 27	E. G. T	Fort Collins	From larvæ under boards, April 20.
2509	May 26	C. P. G	Fort Collins	Taken in foothills.
2524	May 28	C. P. G	Fort Collins	General collecting.
2526	May 31	C. P. G	Fort Collins	Taken at light.
2527	June 1	C. P. G	Fort Collins	Taken at light.
2528	May 28	C. P. G	Fort Collins	Taken at light.
2550	June 8	E. G. T	Fort Collins	Taken at light.
2553	June 9	C. P. G	Fort Collins	Taken at light.
2560	June 11	E. G. T	Fort Collins	Taken at light.
2564	May 14	C. P. G	Fort Collins	Taken in foothills.
2565	June 12	C. P. G	Rist Canon	General collecting.
2567	June 14	E. G. T	Fort Collins	Taken at light.
2570	June 16	E. G. T	Fort Collins	Taken at light.
2571	June 17	E. G. T	Fort Collins	Taken at light.
2573	June 18	E. G. T	Fort Collins	Ta en at light.
2576	June 20	E. G. T	Fort Collins	Taken at light.
2578	June 21	E. G. T	Fort Collins	Taken at light.
2586	June 22	E. G. T	Fort Collins	Taken at light.
2587	June 23	E. G. T	Fort Collins	Taken on plum.
2603	June 25	E. G. T	Fort Collins	Taken at light.
2604	June 26	E. G. T	Fort Collins	At light.
2610	June 30	E. G. T	Fort Collins	Taken at light.
2612	July 1	E. G. T	Fort Collins	Taken under boards in larvæ state.
2613	July 1	E. T. G	Fort Collins	Taken at light.
2614	July 2	E. G. T	Fort Collins	Taken at light.
2615	July 2	E. G. T	Fort Collins	Taken under ground near cabbage, June 18
2617	July 3	E. G. T	Fort Collins	Taken in foothills.
2620	July 7	E. G. T	Fort Collins	Taken at light.
2621	July 6	E. G. T	Fort Collins	Taken at light.
2622	July 4	E. G. T	Fort Collins	Under bark of cottonwood, June 7.
2625	July 5	E. G. T	Fort Collins	Taken at light.
2633	July 9	E. G. T	Fort Collins	Larvæ from flower bed, May 25. Fed alfalfa.
2634	July 7	C. P. G	Fort Collins	On leaves of plum, June 25.
2637	July 10	E. G. T	Fort Collins	Taken at light.
2645	July 4	E. G. T	Fort Collins	Under bark of cottonwood, June 7.
2647	July 14	E. G. T	Fort Collins	Taken at light.
2648	July 15	E. G. T	Fort Collins	From larvæ under boards, May 4. Fed cottonwood.
2650	July 14	E. G. T	Fort Collins	Taken under bands on cottonwood, in pupa state.
2651	July 15	E. G. T	Fort Collins	Taken at light.
2652	July 16	E. G. T	Fort Collins	Taken at light.
2653	July 17	E. G. T	Fort Collins	Taken at sugar.
2654	July 17	E. G. T	Fort Collins	Taken at light.

* Emma A. Gillette.

Cat. Nos.	Dates of Captures.	Collectors.	Localities.	Remarks.
2657	July 14	E. G. T.	Fort Collins	Larvæ under cottonwood bark, June 11.
2659	July 20	E. G. T.	Fort Collins	Taken at light.
2661	July 21	E. G. T.	Fort Collins	Taken at sugar.
2662	July 21	E. G. T.	Fort Collins	Taken at light.
2663	July 22	E. G. T.	Fort Collins	Taken at light.
2664	July 22	E. G. T.	Fort Collins	Taken on sidewalk.
2666	July 24	E. G. T.	Fort Collins	Taken at light.
2670	July 26	E. G. T.	Fort Collins	Taken at light.
2674	July 26	E. G. T.	Fort Collins	Larvæ on ash, June 26.
2676	July 27	E. G. T.	Fort Collins	Taken at light.
2679	July 29	E. G. T.	Fort Collins	Taken at light.
2682	July 15	C. P. G.	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2683	July 12	C. P. G.	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2684	July 15	E. A. G.	Estes Park	Taken at Gem Lake, altitude 9,000 feet.
2685	July 20	E. G. T.	Fort Collins	Taken at light.
2686	July 23	E. A. G.	Estes Park	Taken in Devil's Gulch.
2688	July 30	C. P. G.	Fort Collins	Taken on window.
2689	July 31	E. G. T.	Fort Collins	Taken at light.
2691	Aug. 2	E. G. T.	Fort Collins	Taken at light.
2692	Aug. 2	E. G. T.	Fort Collins	Taken at sugar.
2693	——	W. T. P.	Estes Park	
2694	——	J. H.*	Pinewood	
2695	July —	Mrs. T.†	Laporte	
2696	July 3	E. G. T.	Fort Collins	Taken at light.
2699	Aug. 5	E. G. T.	Fort Collins	Taken at light.
2700	Aug. 5	E. G. T.	Fort Collins	Taken at sugar.
2708	Aug. 6	E. G. T.	Fort Collins	Taken at light.
2709	Aug. 7	E. G. T.	Fort Collins	Taken at light.
2710	July 25	R. N. U.‡	Fort Collins	General collecting.
2713	July 11	E. G. T.	Fort Collins	Taken at light
2715	Aug. 13	E. G. T.	Fort Collins	Taken at light.
2719	Aug. 14	E. G. T.	Fort Collins	Taken at light.
2721	Aug. 10	C. P. G.	Rocky Ford	General collecting.
2722	Aug. 16	E. G. T.	Fort Collins	At light.
2730	Aug. 18	E. G. T.	Fort Collins	At light.
2731	Aug. 19	E. G. T.	Fort Collins	At light.
2733	Aug. 20	E. G. T.	Fort Collins	At light.
2734	Aug. 21	E. G. T.	Fort Collins	At light.
2737	Aug. 24	E. G. T.	Fort Collins	At light.
2738	——	P. S.	Loveland	General collecting.
2743	July 26	E. G. T.	Fort Collins	At light.
2748	Aug. 27	E. G. T.	Fort Collins	At light.
2750	Aug. 28	E. G. T.	Fort Collins	At light.
2751	Aug. 30	E. G. T.	Fort Collins	At light.
2752	Aug. 31	E. G. T.	Fort Collins	At light.
2753	Sept. 1	E. G. T.	Fort Collins	At light.
2754	July 12	E. A. G.	Estes Park	Altitude 8,000 feet.
2755	July 20	C. P. G.	Estes Park	Altitude 8,000 feet.
2756	July 17	E. A. G.	Estes Park	Altitude 8,000 feet.
2758	Aug. 2	E. G. T.	Fort Collins	At light.
2759	Aug. 3	E. G. T.	Fort Collins	At light.
2763	Sept. 4	E. G. T.	Fort Collins	At light.
2764	Sept. 7	E. G. T.	Fort Collins	At light.
2765	July 15	E. A. G.	Estes Park	
2768	Sept. 15	C. P. G.	Fort Collins	Miscellaneous collecting.
2787	Sept. 25	C. P. G.	Greeeley	On nursery stock—apple.
2806	——	——	Colorado	Specimens from David Bruce, and credited by him to Colorado.

* James Heukaufer.
† Mrs. Taft.
‡ R. N. Underwood.



LANTERN TRAP.

This lantern trap was used to collect many of the moths reported in this bulletin.

For a description of the trap see "Proceedings of the Ninth Annual Meeting of the Association of Economic Entomologists," p. 75.

II.

A Few New Species of Deltocephalus and Athysanus from Colorado.

CLARENCE P. GILLETTE.

DELTOCEPHALUS PARVULUS, n. sp.

Color greenish yellow, vertex strongly produced and acute, length $2\frac{1}{2}$ to 3 m. m.

Vertex strongly produced, acute, angle at the apex about eighty degrees, surface nearly flat but not depressed, length somewhat exceeding the distance between the eyes; color whitish, with two irregular, diverging, infuscate bands extending from the apex to the posterior margin, median line black and sharply defined on the posterior two-thirds. Front slightly infuscate, with about six interrupted, transverse, pale yellow arcs; clypeus pale yellow or slightly infuscate, broadest at base and gradually narrowing to the rounded apex; genæ greenish yellow throughout with a black spot just outside the middle of the loral suture, in some examples the upper part of the suture is also black. Entire length of the face slightly exceeding the width. Pronotum pale yellowish green, deeper yellow on the anterior margin, in some examples with two longitudinal black dashes above; the length hardly equal to one-half of the width, but slightly exceeding that of the vertex. Scutellum pale yellowish. Elytra deep yellowish green, subhyaline, considerably exceeding the abdomen; nervures very distinct and deeper yellowish green. Tergum black, with the lateral margins of the segments pale yellow. Venter yellowish green with little or no dark shading, last ventral segment broadly produced and oval at the tip. Pygofers and ovipositor yellowish white, the latter bordered with black beneath in some specimens. Legs pale yellowish white throughout.

Male genitalia: Valve rather small, triangular, the apex blunt, the base extending from one-half to two-thirds of the distance across the hind margin of the preceding ventral segment; plates long and rather slender, extending beyond the valve a distance about equal

to twice the length of the latter, and possessing a single row of rather stout, pale yellow spines along the outer margins; color pale greenish yellow. [See fig. 1.]

Described from fifteen females and five males taken by the writer sweeping native plants, in most cases short prairie grass, between August 16th and October 7th, and on May 28th. The points from which specimens were taken are Fort Collins, Colorado Springs,

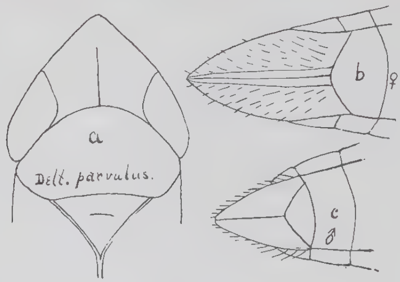


FIG. 1.

Deltocephalus parvulus: (a) upper surface of vertex, pronotum and scutellum; (b) female genitalia from beneath; (c) male genitalia from beneath. Grealty enlarged (original).

New Windsor, and Horsetooth Gulch. This species is a rival of *minimus* O. & B. in minuteness, which species it closely resembles. It is readily distinguished, however, by the broadly rounded, unicolorous, entire last ventral segment of the female, and the smaller, more acute valve in the male.

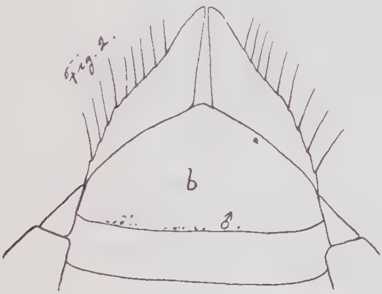
DELTOCEPHALUS COOKEI, n. sp.

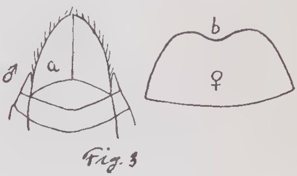
Color cinereous to grayish brown, vertex with dark markings, length $2\frac{1}{4}$ m. m.

Vertex broad, flat, not distinctly depressed nor strongly produced, rounded at the apex; color pale yellowish, variously flecked with dark brown, median line nearly obsolete, length barely equaling the distance between the eyes and less than one-half the width of the head. Front pale brown, with about six incomplete transverse bars, and nearly parallel sided, rather narrow, width at clypeus fully one-half the width at the ocelli; labrum sordid yellow, in most examples streaked with black on the middle, nearly parallel sided, broadest near the rounded apex; genæ sordid yellow streaked with black beneath the eyes, next the antennæ, and along the loral suture; the inferior angle of the loræ black in some examples, in others entirely yellow; genæ, below the loræ, very narrow. Pronotum on the anterior margin, concolorous with the vertex, darker posteriorly, in some examples nearly unicolorous and in others with a distinct longitudinal dark stripe back of the inner angle of the eye; still others are marked with a small black spot on the anterior margin against the middle of each eye and have from one to three

smaller spots posterior to these and directly behind the inner angle of the eye; distinctly longer than the vertex and a little more than twice as wide as long, Scutellum of the same color as the pronotum, with or without yellow and dusky markings, transverse suture very close to the hind margin of the pronotum. Elytra slightly exceeding the abdomen, pale cinereous, with a few dusky or black dashes within the cells, the heaviest one on the clavus near the suture, rather near the base. In some examples this is the only dark coloration present. Tergum black on basal half, mostly yellow on the last two segments. Pectus and venter almost entirely black; last ventral segment of the female black, short, distinctly inflated, posterior angles, produced and with a short, blunt median lobe; ovipositor yellow on the middle and basal portion, darker towards the tip, slightly exceeding the pygofers. Legs smoky yellow, femora and coxæ mostly black.

Male: With the valve large and broad, with a slight tooth at the apex; plates stout at the base, suddenly constricted before the apex and exceeding the valve by nearly its own length.





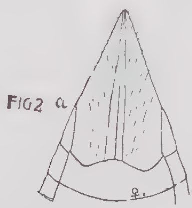


FIG. 2.—*Deltocephalus cookei:* (a) female genitalia from beneath; (b) male genitalia from beneath. Greatly enlarged (original).

FIG. 3.—*Deltocephalus vanduzei:* (a) genitalia of the male from beneath; (b) last ventral segment of the female from beneath. Greatly enlarged (original).

Described from seven males and five females taken at Manhattan, Colo., October 7th, by Prof. W. W. Cooke, to whom I take pleasure in dedicating this species. It is closely related to *vanduzei* G. & B., but is readily separated from the latter by the markings upon the vertex and the genital characters, as well as its usual lighter color. In venation this species is an *Athysanus*, but the vertex and face, especially the latter, are Deltocephaloid in form. [See figs. 2 and 3.]

DELTOCEPHALUS BLANDUS, n. sp.

Pearl gray, marked with cinnamon brown. Length $2\frac{1}{2}$ m. m. Vertex with a broad white median stripe divided by a brown line on the posterior two-thirds and bordered either side by a broader band of brown in which are two whitish spots, giving the brown color somewhat the shape or the letter B. Near the base of the vertex, either side of the white stripe, are two small deeply colored chocolate spots; ocelli black. Face light cinnamon brown in color with about six irregular transverse pale lines, and about one-sixth longer than broad; clypeus broadest at base and gradually narrowing to a rounded apex; loræ whitish with a large central dark spot; genæ whitish, black beneath the antennæ and moderately broad at the clypeus. Pronotum pale yellowish green, faintly stained with chocolate, slightly concave behind, lateral margins broadly rounded and two and one-fourth times as broad as long. Scutellum concolorous with pronotum, with the basal angles and two longitudinal parallel lines on the disc pale chocolate in color, transverse suture straight. Elytra attaining the posterior margin of the last abdominal segment, pale ashy in color with a few of the nervures bordered with pale brown. The tergum light brown, mottled with white along the median line, the basal portion of the pygofers above deeper brown than the rest, shading into black on the anterior margin. Venter black on the middle and yellow at sides; pygofers pale yellow stained with brown below; ovipositor black, scarcely exceeding the pygofers; last ventral segment with posterior angles produced and rounded and with a short blunt median tooth, the tooth and broad lateral margins of the segment white, the remaining portion black; feet pale yellow spotted and annulate with cinnamon brown.

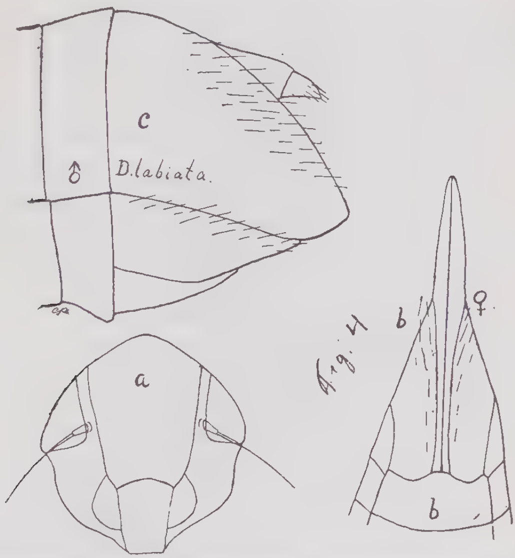
A very handsome species described from two females taken by the writer, one at Fort Collins, September 21st, and one at Calhan, October 7th, while sweeping native grass.

DELTOCEPHALUS LABIATA, n. sp.

Somewhat closely resembling *D. argenteolus* Uhl., but differing in having a narrow and more acute vertex that is not at all depressed above. Length $3\frac{1}{2}$ m. m.

Female: Vertex nearly flat but not depressed between the eyes, slightly sloping forward, conical at the apex, about one-fourth longer than the distance between the eyes, whitish to light lemon yellow in color, with light and brown pencilings on anterior third, ocelli fuscous or black. Front concolorous with vertex with about six more or less distinct dark cross lines, which are interrupted on the middle; clypeus long, lateral sutures straight, a little broadest at base, truncate at apex, extending about one-third of its length beyond the loræ; genæ ivory white with a black spot beneath the antennæ, another beneath the middle of the eye, and a third very

small one on the middle of the loral suture, narrow below the loræ but, on meeting the clypeus, suddenly expanding and extending to its apex; loræ and clypeus entirely yellow, or with their lower ends blackened; entire length of face distinctly greater than the width. Pronotum colored like the vertex on the anterior margin but shading into greenish posteriorly, rather indistinctly transversely wrinkled on the posterior half, nearly three times as wide as long. Scutellum small, greenish or yellowish without markings, transverse groove rather faint. Elytra of same color as the vertex, about as broad as long, barely reaching the third abdominal segment. First two abdominal segments black above, the following ones light yellow, each having a transverse row of from six to eight light brown spots, except the last segment, which usually has no dark markings. One example has two spots, as in *D. argenteolus* Uhl., and also has black lateral margins at the penultimate segment. Venter black on the middle, yellow at the sides, posterior angles of last segment slightly



Deltocephalus labiata: (a) face; (b) genitalia of female from beneath; (c) genitalia of male from the side. All greatly enlarged (original).

produced, the middle lobe occupying more than half of the hind margin. Pygofers pale yellow, ovipositor about three-eights of the entire length of the body and strongly exserted. Legs pale yellow, in dark specimens tinged with brown.

Males: The males differ from the females in being only $2\frac{1}{2}$ m. m. long and being much darker in color; the lower half of clypeus and loræ, the venter, and the tergum, except the last segment, which is white, black. The elytra are darker than in the females, with the

nervures near the posterior margin conspicuously white. The ground color of the vertex is more reddish and the light markings are more distinct on account of darker brown colors bordering them. The valve of the genital pieces is triangular, narrow at the base, with the apex slender and acute; the plates are short and stout and exceed the valve but little. [See fig. 4.]

Described from numerous examples of both sexes taken by the writer during the months of April, May, September and October, sweeping native plants and in the following localities in the state: Fort Collins, Bellvue, Manhattan and Calhan.

Variety *rufus*.—Of this species I have three females that differ from the others in being of a salmon color throughout, with the markings indistinct.

DELTOCEPHALUS ATROPUNCTA, n. sp.

Pale yellow in color, vertex strongly produced with a black spot at apex. Length $3\frac{1}{3}$ m. m.

Vertex strongly produced, acute, slightly elevated towards the apex, disc slightly convex between the eyes, not at all depressed, length equal to one and one-half times the distance between the eyes. Color light yellow shaded with brown towards the apex, paler between the eyes, median stripe and two cross bars whitish, median dark line obsolete except at the base; ocelli black. Front long and narrow, nearly parallel sided, pale yellow in color with fuscous cross lines rather indistinct in one specimen and nearly black in another. Clypeus rather long, sides parallel, tip truncate and strongly produced beyond the loræ, pale yellow in color, infuscate towards the tip; loræ and genæ pale yellow, except that the latter have a black streak under either eye near the antenna, a smaller black spot beneath the middle of the eye and a black coloration in the very narrow portion below the loræ; entire length of the face fully one-fourth greater than the breadth.

Pronotum light yellow, feebly striated posteriorly, length a little more than one-third of the width. Scutellum pale yellow. Elytra pale yellow without markings, reaching the middle of the third abdominal segment. Tergum yellow with a black spot midway on the sides of the first segment and indistinct transverse rows of brown spots on the succeeding segments. Venter yellow, with the last segment, only, brownish in one example, and in another the middle of the hind margin is nearly black. The last ventral segment is large, posterior angles somewhat acute and hind margin somewhat produced, and very similar to that of the preceding species. It is readily separated from *labiata* by the greater length of the face, the more produced vertex and the black spot at the tip of the latter.

Described from two females, one taken by Emma A. Gillette at

Laporte, Colorado, May 17th, and one taken by the writer at Fort Collins, Sept. 27th. Both obtained by sweeping native plants.

It is not improbable that this species and the preceding may have to be taken out of the genus *Deltocephalus.* A study of long-winged forms, which probably exist, would help to settle the matter. The short elytra and greatly exserted ovipositors are strikingly similar to those parts in *Deltocephalus argenteolus* Uhl., and *Athysanus curtipennis* G. & B., but the conical shape of the vertex and the strongly produced clypeus is in contrast with those species and also with the species of the genus *Doratura*, J. Sahlb.

ATHYSANUS ORNATUS, n. sp.

A shining black species with posterior portion of the pronotum and the elytra, except three transverse black lines, white. Length 3 m. m. Vertex very broadly rounded, the length a little less than the distance between the eyes and almost exactly equaling the length of the pronotum; color polished black. Face of the same color as the vertex, except that there are two spots on the base of the clypeus, one near the angle of each cheek, and about eight interrupted cross lines on the front that are of a yellowish brown color. Front short and broad, rapidly narrowing to the clypeus; clypeus rounding at the base, parallel sided, truncate at the tip. Entire width of the face once and one-fifth the length. Pronotum shining black on anterior third, pale yellow on posterior two-thirds, and two and one-half times as wide as long. Scutellum black with the apex white. Elytra short, just covering the last segment of the tergum, the corium but little exceeding the clavus; in color glaucus white, with the extreme base, the tip, and a transverse band on the middle of each, shining black. Tergum deep shining black; venter mostly yellow, the bases of the segments more or less black, the last segment entirely black and a little concave on the hind margin; pygofers and ovipositor glossy black and short. Legs blue black with considerable yellowish brown coloration.

Described from a single female, example taken by the writer at Fort Collins, May 28th, sweeping native plants.

This is a very handsome species, and is readily recognized by the black head and white wing covers with the three tranverse black lines.

III.

LIST OF ORIGINAL TYPES OF SPECIES IN THE SUPERFAMILY JASSOIDEA

Now in the Collections of The Colorado Agricultural College and Agricultural Experiment Station.

CLARENCE P. GILLETTE.

The list given below is for the information of students in entomology and also for the purpose of correcting a statement in regard to "true type specimens" made by Mr. C. F. Baker in an article headed "Notes on the Genus Deltocephalus" and published in the current volume of "Psyche," p. 114.

I must also add that our missing types mentioned in that article, along with numerous other specimens that seem to have accompanied them, were "removed" without permission of anyone in authority, from the cabinets of this institution, where they still belong. Most of my own species, given below in the sub-family *Typhlocybinæ,* are unpublished at this writing but the descriptions are all in type and will soon appear in a paper from the United States National Museum, entitled "American Leaf-Hoppers of the Sub-family Typhlocybinæ."

Family BYTHOSCOPIDAE.

Pediopsis erythrocephalus G. & B.—1 female.
Pediopsis sordida V. D.—2 females and 1 male.
Idiocerus amœnus V. D.—1 female.
Idiocerus perplexus G. & B.—2 females.
Idiocerus productus G. & B.—1 male.
Idiocerus snowi G. & B.—1 male.
Idiocerus rufus G. & B.—1 female.
Agallia cinerea O. & B.—4 females and 4 males.
Agallia gillettei O. & B.—12 females and 5 males.

Family JASSIDAE.

Acocephalus maculatus G. & B.—1 female.
Deltocephalus auratus G. & B.—3 males.
Deltocephalus bilineatus G. & B.—2 females.
Deltocephalus albidus O. & B.—2 females and 2 males.
Deltocephalus reflexus O. & B.—2 females and 2 males.
Deltocephalus pectinatus O. & B.—2 females and 2 males.
Deltocephalus abbreviatus O. & B.—2 females and 2 males.
Deltocephalus compactus O. & B.—2 females and 2 males.
Deltocephalus sylvestris O. & B.—2 females and 2 males.
Deltocephalus oculatus O. & B.—2 females and 2 males.
Deltocephalus minimus O. & B.—2 females and 2 males.
Deltocephalus monticola G. & B.—1 female.
Deltocephalus parvulus Gill.—12 females and 3 males.
Deltocephalus blanda Gill.—2 females.
Deltocephalus vanduzei G. & B.—1 male.
Deltocephalus cookii Gill.—5 females and 5 males.
Deltocephalus nigrifrons Forbes—1 female.
Deltocephalus bimaculatus G. & B.—2 males.
Deltocephalus flavovirens G. & B.—1 male.
Deltocephalus labiata Gill. 22 females and 14 males.
Deltocephalus atropuncta Gill.—2 females.
Allygus coloradensis G. & B.—1 male.
Athysanus curtipennis G. & B —1 female.
Athysanus artemisiæ G. & B.—1 female.
Athysanus relativus G. & B.—2 females.
Athysanus dentatus O. & B.—2 females and 1 male.
Athysanus colon O. & B.—2 females and 2 males.
Athysanus punctatus O. & B.—2 females.
Athysanus ornatus Gill.—1 female.
Driotura robusta O. & B.—2 females and 1 male.
Eutettix querci G. & B.—1 male and 1 female.
Eutettix clarivida V. D.—1 female.
Phlepsius altus O. & B.—2 females and 2 males.
Thamnotettix caricis G. & B.—1 male.
Thamnotettix sonoræ G. & B.—1 female.
Neocœlidea tumidifrons G. & B.—2 males.
Gnathodus confusus G. & B.—2 females.
Gnathodus manitou G. & B.—1 male.
Cicadula arcuata G. & B.—1 female and 1 male.
Alebra fumida Gill.—1 male.
Dicraneura cockerellii Gill.—3 females and 3 males.
Dicraneura cruentata Gill.—3 females and 2 males.
Dicraneura communis Gill.—2 females and 1 male.
Dicraneura kunzei Gill.—1 female and 2 males.
Dicraneura unipuncta Gill.—1 female.
Empoasca trifasciata Gill.—5 females and 2 males.
Empoasca clypeata G. & B.—3 males.
Empoasca nigra G. & B.—2 males.
Empoasca pulchella G. & B.—1 female.
Empoasca albolinea Gill.—7 females.
Empoasca denticula Gill.—1 female.
Empoasca unicolor Gill.—18 females and 2 males.
Empoasca atrolabes Gill.—20 females.
Empoasca pallida Gill.—2 females.
Empoasca alboneura Gill.—12 female and 8 males.
Empoasca aspersa G. & B. (tessellata Leth.)—4 females and 2 males.
Empoasca flavescens Fab., var. birdii Godg.—2 females and 1 male.
Empoasca robusta Gill.—2 females.
Empoasca nigroscuta G. & B.—2 females.
Empoasca nigroscuta, var. typhlocyboids G. & B. —2 males.
Eupteryx flavoscuta Gill.—2 females.
Eupteryx vanduzei Gill.—3 females.
Typhlocyba sanguinea G. & B.—1 female.
Typhlocyba hartii Gill.—2 males.
Typhlocyba rubroscuta Gill.—12 females and 4 males.
Typhlocyba crevecœuri Gill.—8 females and 4 males.
Typhlocyba obliqua, Say, var. dorsalis Gill.—2 females and 1 male.
Typhlocyba obliqua, Say, var. nævus Gill.—1 female and 1 male.
Typhlocyba obliqua, Say, var. fumida Gill.—4 females and 2 males.
Typhlocyba comes, Say, var. illinoiensis Gill.—8 females and 4 males.
Typhlocyba comes, Say, var. coloradensis Gill.—5 females aud 2 males.
Typhlocyba comes, Say, var. maculata Gill.—3 females and 1 male.
Typhlocyba comes, Say, var. scutelleris Gill.—2 females.
Typhlocyba comes, Say, var. rubra Gill.—11 females and 1 male.
Typhlocyba comes, Say, var. infuscata Gill.—4 females and 1 male.
Typhlocyba vulnerata, Fitch, var. niger Gill.—2 females and 4 males.
Typhlocyba dentata Gill.—1 female.
Typhlocyba flavomarginata G. & B.—1 female.

The State Agricultural College

THE AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 44

TECHNICAL SERIES No. 4

FURTHER NOTES

ON THE

Birds of Colorado

An Appendix to Bulletin No. 37, on the Birds of Colorado

BY

W. W. COOKE

APPROVED BY THE STATION COUNCIL

ALSTON ELLIS, President

FORT COLLINS, COLORADO

MARCH, 1898

THE SMITH-BROOKS PRINTING COMPANY
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THE

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FORT COLLINS, COLORADO

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FURTHER NOTES

ON

THE BIRDS OF COLORADO.

BY W. W. COOKE.

On the publication in March, 1897, of Bulletin No. 37 of this Station, entitled "The Birds of Colorado," the author received many letters containing additional notes. These led to quite an extensive correspondence and in several cases the examination or re-examination of large series of specimens. In addition the present writer has had a chance to personally examine several small collections not before accessible to him.

The results of this investigation are presented in the following pages. Even with these additions it is practically certain that the Colorado list will yet receive many new species.

All references are to the pages of the original edition to which this bulletin is to be considered as an appendix. On page 3, the total number of species and varieties known to occur in Colorado should be changed to 374, of which 236 are known to breed.

CLASSIFICATION OF COLORADO BIRDS.

Changes to be made, including those already made in the Addenda on page 128.

Page 8. **1. Residents:** Add

Phasianus torquatus.

Page 10. **4. Species that have been taken in Colorado in winter, either as rare or accidental visitors.** Add

Somateria dresseri.
Nyctala tengmalmi richardsoni.
Acanthis linaria rostrata.

Page 11. *B. Species that breed on the plains, but only to the foot-hills of the mountains.* Add

Philohela minor.
Phasianus torquatus.
Phalænoptilus nuttallii nitidus.
Habia ludoviciana.
Helminthophila peregrina.
Harporhynchus bendirei.

Page 12. *D. Species that breed principally in the mountains.* Add

Empidonax hammondi.

Page 13. *E. Species that breed regularly only in Southern Colorado.* Add

Plegadis guarauna.

Page 13. **6. Species taken in the State during the summer, but not known to breed.** Omit

Plegadis guarauna.
Philohela minor.
Phalænoptilus nuttallii nitidus.

Add

Tympanuchus americanus.
Stellula calliope.
Melospiza georgiana.

Page 13. **7. Migrants.** Add

Urinator adamsii.
Porzana jamaicensis.
Piranga erythromelas.
Dendroica palmarun.

Omit

Helminthophila peregrina.
Harporhynchus bendirei.

Page 14. **8. Stragglers or doubtful species.** Add

Urinator adamsii.
Somateria dresseri.
Porzana jamaicensis.
Nyctala tengmalmi richardsoni.
Bubo virginianus articus.
Coccyzus americanus.
Dryobates pubescens.
Stellula calliope.
Acanthis linaria rostrata.
Melospiza georgiana.
Piranga erythromelas.
Dendroica palmarum.

Omit

Harporhynchus bendirei.

Page 15. **10. Rare or irregular visitants, from the east or southeast.** Add

Tympanuchus americanus.
Melospiza georgiana.

Habia ludoviciana.
Piranga erythromelas.
Dendroica palmarum.

Page 16. **12. Rare or irregular visitants from the west or southwest.** Add

Stellula calliope.

Add the star (*) to denote breeding, to
Plegadis guarauna.

Page 16. **SUMMARY.**

Total species in Colorado	374
1. Residents	88
2. Regular winter visitants from the north	24
3. Regular breeders that sometimes occur in winter	17
4. Rare or accidental winter visitants	25
5. Summer residents	236
A. Breeding on plains and in mountains	101
B. Breeding on plains, but not in mountains	40
C. Breeding in mountains, but not on plains	53
D. Breeding principally in mountains, sparingly on plains	21
E. Breeding regularly only in southern Colorado	21
6. Summer visitants, not known to breed	15
7. Migrants	60
8. Stragglers	59
9. Regular visitants from east and southeast	14
10. Rare visitants from east and southeast	38
11. Regular visitants from west and southwest	20
12. Rare visitants from west and southwest	13

BIBLIOGRAPHY OF COLORADO ORNITHOLOGY.

Page 25. Add. BERTHOUD, E. L. Birds, their Geological History, Migration and Uses. By E. L. Berthoud, A. M., Member Phila. Academy and N. Y. Academy of Sciences. *Transcript Print*, Golden, Colo. [Issued in 1887.]

Short notes on twenty-four species of Colorado birds with reference to their distribution and migration. Includes the Wild Turkey and the Carolina Paroquet.

Page 27. Add. COCKERELL, T. D. A. The Food of Some Colorado Birds. *Am. Nat. XXV.* 1896, *p. 329.*

Examinations of the stomach contents of eleven species, taken by W. P. Lowe in various places in southern Colorado.

Page 27. Add. W. W. COOKE. The State Agricultural College, The Agricultural Experiment Station, Bulletin No. 37, Technical Series No. 2, The Birds of Colorado. By W. W. Cooke. Approved by the Station Council. Alston Ellis, President. Fort Collins, Colorado, March, 1897. The Smith-Brooks Printing Company, Denver, *pp. 144.* [Date of distribution, March 14, 1897.]

Contains an introduction on the general bird life of the State; Classification; giving lists of the birds with reference to their distribution and breeding. Dates of migration; a comparison of migration in different parts of Colorado with dates of arrival of the same species at St. Louis. Bibliography of Colorado ornithology; references to 182 books and articles. History of Colorado ornithology; giving the authority, date and place of publication for the introduction of each species into the list of Colorado birds. Birds of Colorado; being a list with brief annotations of the 363 species known to occur in the State.

COOKE, W. W. The Scarlet Ibis in Colorado. *Auk, XIV.* 1897, *p. 316.*

Note on the alleged occurrence of this species in the Arkansas Valley. The article is based on a mis-identification, the birds taken being really the White-faced Glossy Ibis.

COOKE, W. W. Bendire's Thrasher in Colorado. *Osprey, II.* 1897, *p. 7.*

Nests and eggs taken by Mr. N. R. Christie at Rouse Junction.

COOKE, W. W. A New Bird for Colorado. *Oregon Naturalist, IV.* 1897-8, *p. 65.*

A specimen of the Calliope Hummingbird found at Colorado Springs, July 25, 1897.

Page 29. Add. COUES, ELLIOTT. The Expeditions of Zebulon Montgomery Pike, To Headwaters of the Mississippi River, Through Louisiana Territory and in New Spain, During the Years 1805-6-7. A New Edition . . . . . by Elliott Coues . . . . In Three Volumes. Vol. II. Arkansas Journey—Mexican Tour. New York, Francis P. Harper, 1895, pp. 955.

Contains the same bird notes as the original edition with the addition of a specific name to the description of the Carolina Paroquet.

Page 30. Add. Editorial. *The Republican*, April 29, 1897. [Local newspaper, published at Rocky Ford, Colo.]

Note of a Scarlet Ibis killed in that vicinity a few days before and mounted by Bert Beymer. [Specimen was really the White-faced Glossy Ibis.]

Editorial. *The Republican*, June 3, 1897.

Further notes on the capture of the birds mentioned in a previous issue with the same error of identification.

EVERMANN, B. W. and Jenkins, O. P. Ornithology from a Railroad Train. *O. & O. XIII.* 1888, *pp. 65.*

Notes on twenty-one species of birds seen on a trip through the Arkansas Valley and up the Las Animas River to Trinidad.

Page 33. Add. INGRAHAM, D. P. Additional Records of the Flammulated Owl (*Megascops flammeola*) in Colorado. *Auk, XIV.* 1897, *p. 403.*

Two sets of eggs taken in May, 1897, near Beulah.

Page 34. Add. MORRISON. C. F. The Tricolored Blackbird in Colorado. *O. & O. XII.* 1887, *p. 107.*

Birds supposed to have been seen near Fort Lewis, February 3, 1887.

Page 35. Add. PIKE, Z. M. Exploratory Travels through the Western Territories of North America: comprising a Voyage from St. Louis, on the Mississippi, to the Source of that River, and a Journey through the Interior of Louisiana and the north-eastern Provinces of New Spain. Performed in the years 1805, 1806, 1807, by Order of the Government of the United States. By Zebulon Montgomery Pike, Major 6th Regt. United States Infantry. London: Paternoster Row. 1811. Denver: W. H. Lawrence & Co. 1889.

This is a reprint of the second edition. The book lays no claim to scientific ornithology, but it is interesting as being the first book that makes specific references to Colorado birds. Five species are mentioned or described.

Page 36. Add. RIDGWAY, ROBERT. A Monograph of the Genus *Leucosticte*, Swainson: or, Gray-crowned Purple

Finches. *Bull. Geol. and Geog. Surv. Ter. No. 2. Second Series.* May 11, 1875. *pp. 51-82.*

A full discussion of the three species and two varieties that inhabit the United States. Four of these forms are found in Colorado and three-fourths of the specimens that form the basis of the monograph came from Colorado.

Page 38. Add. SPRAGUE, U. [=W.] A. The Dwarf Thrush in Colorado. *Auk, XIII.* 1896, *p. 85.*

One taken at Magnolia, October 6, 1895, and identified by Ridgway.

THE HISTORY OF COLORADO ORNITHOLOGY.

Page 48. Add.

1898. **Cooke.** *Oregon Naturalist, IV.* 1897-8, *p. 65.* *Stellula calliope* taken at Colorado Springs and reported by C. E. Aiken.

1898. **Cooke.** *Colorado Experiment Station Bulletin No. 44.* The present publication contains the first records for Colorado of ten species as follows: *Phasianus torquatus* and *Melospiza georgiana* by Aiken; *Habia ludoviciana* by Mrs. Bacon; *Porzana jamaicensis* by Bruce; *Piranga erythromelas* by Cooke; *Nyctala tengmalmi richardsoni* by Doertenbach; *Urinator adamsii* by Hardy; *Tympanuchus americanus* by Robertson; *Dendroica palmarun* by H. G. Smith, and *Acanthis linaria rostrata* by Sprague.

Page 48. **RECAPITULATION.** Add.

1898	W. W. Cooke	1	364
1898	W. W. Cooke	10	374

THE BIRDS OF COLORADO.

Page 49. 1. **Æchmophorus occidentalis.** WESTERN GREBE.

In a collection of beautifully mounted birds at the High School building at Cheyenne, Wyo., is a fine specimen of this species, that was brought to Mr. F. Bond in the flesh and mounted by him, as were the other birds in this collection. Mr. Bond writes that years when he has been collecting he has seen a few in autumn on the lakes near Cheyenne. This record, taken in connection with that already published, would indicate that this species was quite regular in visiting the eastern slope of the range, though never common.

Page 49. 2. **Colymbus holbœllii.** HOLBŒLL'S GREBE.

The same collection contains one of these birds, shot in the vicinity by Mr. Bond, who has also seen several others in autumn on the lakes. As Cheyenne is only just over the Colorado line, these records make it probable that this species will eventually be taken in Colorado east of the range.

Page 49. 3. **Colymbus auritus.** HORNED GREBE.

Mr. E. L. Berthoud writes that he has seen two specimens that were killed on the lakes northeast of Golden.

Page 50. Add. 8. **Urinator adamsii.** YELLOW-BILLED LOON.

Migratory; rare or accidental. In the collection of Mr. Manly Hardy, Brewer, Me., there is a young male of this species taken May 25, 1885, at Loveland, Colo., by W. G. Smith. Mr. Hardy writes that there can be no question whatever of the identity of the specimen. This is the first record for Colorado, and a very strange record, since the species inhabits Arctic America and is rarely found anywhere in the United States.

Page 51. 60. **Larus philadelphia.** BONAPARTE'S GULL.

To previous records add one taken November 15, 1895, at Pueblo by Mr. H. W. Nash; also one taken and several others seen by Mr. F. Bond at Cheyenne.

Page 51. 62. **Xema sabinii.** SABINE'S GULL.

Near Golden in the early days of the settlement of that country Mr. E. L. Berthoud says that these gulls were not uncommon, but have disappeared of late years.

Page 52. 120. **Phalacrocorax dilophus.** DOUBLE-CRESTED CORMORANT.

In the summer of 1897, the Cormorant was found breeding by Prof. Knight, near Buffalo, Wyo. This is quite a long distance north of Colorado, but yet it increases the probability of the bird's occurring as a breeder in this State.

Page 53. 133. **Anas obscura.** BLACK DUCK.

A third specimen can now be recorded. According to Mr. H. G. Smith one was purchased by a local taxidermist in the Denver market December 12, 1894. It is presumed that the bird was shot in Colorado.

Page 53. 135. **Anas strepera.** GADWALL.

Found by Mr. C. E. Aiken as an abundant breeder at the San Luis Lakes.

Page 55. 144. **Aix sponsa.** WOOD DUCK.

A mounted specimen is now in the possession of Mr. E. J. Oslar of Denver, that was taken at Littleton about May 1, 1892.

Page 57. Add. 160. **Somateria dresseri.** AMERICAN EIDER.

One was taken by W. G. Smith at Loveland sometime previous to 1892. Prof. Wm. Osburn writes that he saw the specimen in Mr. Smith's collection.

There is a mounted bird of this species at the rooms of the Society of Natural History in Denver. There is no record accompanying it, but it was presumably taken in Colorado nearly twenty years ago.

Page 58. 172. **Branta canadensis.** CANADA GOOSE.

During the summer of 1897, this species was noted by the present writer as nesting five miles west of NiWot at about 5,500 feet. This is several thousand feet lower than previous records.

Page 60. [185.] **Guara rubra.** SCARLET IBIS.

In the third line, the word "Texas" should be New Mexico, the reference being to the record of Dr. Coues at Albuquerque. The birds reported by Mr. Beymer in the Rocky Ford Republican and by the present writer on his authority in the Auk were really the White-faced Glossy Ibis (*Plegadis guarauna*).

Page 60. 187. **Plegadis guarauna.** WHITE-FACED GLOSSY IBIS.

Summer resident; rare. The number of known occurences is now double what is was a year ago. As stated above the birds seen at Rocky Ford were really this species instead of the Scarlet Ibis. A flock of six were seen there on the Arkansas

River, April 23, 1897, and three of them were secured and have been mounted by Mr. Beymer. A young female, presumably of this species, was taken September 10, 1897, twenty miles east of Pueblo on the Arkansas and reported by W. F. Doertenback of Pueblo. It was not young enough to prove that it had been raised in the vicinity.

In September, 1872, Mr. C. E. Aiken saw one on the South Platte River in South Park at nearly 7,000 feet altitude. On July 1, 1875, Mr. Aiken found this species breeding at the San Luis Lakes at about 7,500 feet altitude, so that it stands at present in the Colorado list as a summer resident.

The known northern range of this species is much extended by the following record. In the spring of 1893, Mr. R. A. Wallen shot one at Red Bank, Wyo., about two hundred miles north of Laramie City.

Page 61. 191. **Ardetta exilis.** LEAST BITTERN.

About August 5, 1897, Mr. W. A. Sprague of Boulder, saw a Least Bittern on a branch of the Grand River in Middle Park eight miles from Buchanan Pass. This is the first and only record for Colorado west of the range. Mr. H. G. Smith has one record of this species for the vicinity of Denver.

Page 61. 194. **Ardea herodias.** GREAT BLUE HERON.

A very late migrant and also at a much higher altitude than the former records is the one reported by Mr. C. E. Aiken at over 9,000 feet on the divide between Colorado Springs and South Park, November 27, 1897.

Page 61. 197. **Ardea candidissima.** SNOWY HERON.

This is probably not so rare a bird as was formerly believed. In addition to the seven records already noted, three specimens of this species were mounted by Mr. W. F. Doertenbach of Pueblo, during the past eight years; he also saw one on the Arkansas near Pueblo, May 9, 1897, and two young birds were sent him October 4, 1897, that were taken within six miles of Pueblo.

Mr. C. E. Aiken adds five more records, two near Leadville, in 1886, one near Denver and two from Pueblo. The Leadville specimens at about 10,000 feet are several thousand feet higher than previous records.

Page 61. 198. **Ardea rufescens.** REDDISH EGRET.

A second record for Colorado comes from Mr. E. L. Berthoud, who shot one near Golden eight years ago.

Page 63. 212. **Rallus virginianus.** VIRGINIA RAIL.

Mr. C. E. Aiken took the nest mentioned near Fountain, El Paso County.

Page 63. Add. 216. **Porzana jamaicensis.** BLACK RAIL.

Migratory; rare. Mr. David Bruce of Brockport, N. Y., who has done a large amount of collecting in Colorado, writes that he has one that he shot in May several years ago at a pond near Denver. He thinks he has seen similar birds several times, but this is the only one he has secured. The Black Rail is a southern species coming north regularly almost to Colorado.

Page 63. 219. **Gallinula galeata.** FLORIDA GALLINULE.

A second record is added by Mr. E. L. Berthoud, who saw one in 1883 at Lathrop's Lake, twelve miles from Golden.

Page 63. [222. **Crymophilus fulicarius.** RED PHALAROPE.

According to the distribution of this species as given in the A. O. U. Check List, it should be found in Colorado, but no specimen has yet been reported. There is one in the collection of the Wyoming State University at Laramie City, that was taken September 14, 1897, at Seven Mile Lakes, Albany County, not far from the Colorado line.]

Page 64. 228. **Philohela minor.** AMERICAN WOODCOCK.

The classification can now be changed to—summer resident; rare. On July 3, 1897, Mr. Harry Horner of Timnath, found near his home a pair of Woodcock and three young. One of the young was caught. They could not have been more than a week old. In addition to the records already published, Mr. E. L. Berthoud writes that he has seen them occasionally in Jefferson and Park Counties, while once he saw them on the Arkansas.

Page 64. 230. **Gallinago delicata.** WILSON'S SNIPE.

Seen twice in the summer of 1897 in Middle Park at about 9,000 feet by Mr. W. A. Sprague of Boulder. Mr. C. E. Aiken found them breeding July 1, 1875, at the San Luis Lakes at an altitude of 7,500 feet. On January 16, 1898, Mr. Aiken saw five of these birds near Colorado Springs, and the same day two men shot fifteen along the banks of the Fountain Creek.

Page 65. 240. **Tringa fuscicollis.** WHITE-RUMPED SANDPIPER.

To previous records add one taken by Mr. Aiken at Colorado Springs and identified by Mr. Ridgway.

Page 66. 248. **Calidris arenaria.** SANDERLING.

One was taken October 1, 1897, by Mr. H. W. Nash near Pueblo. Mr. C. E. Aiken writes that he has known of several taken near Colorado Springs.

Page 70. 300b. **Bonasa umbellus umbelloides.** GRAY RUFFED GROUSE.

One was shot about eighteen miles south of Denver the latter part of December, 1894. It was with several others and they were seen on several occasions. Mr. L. D. Gilmore reports seeing five January 3, 1898, and more on the following week near Sweet Water Lake in Eagle County at 8,000 feet. An old hunter there told him that they are never seen in summer, but come in the winter and are sometimes quite common.

Page 71. Add. 305. **Tympanuchus americanus.** PRAIRIE HEN.

Summer visitant; rare and local. There have been many reports of true "Prairie Chickens" in Colorado, but all reported previous to 1897 have proved on investigation to be Sharp-tailed Grouse. During last October the present writer saw some Prairie Chickens at Ogallala, Neb., some twenty-five miles east of the Colorado line. Diligent inquiry has revealed the fact that they are quite common a little east of Ogallala and decrease suddenly to the westward. More than half of those questioned had never seen one west of that place. They do, however, extend occasionally into Colorado, for Mr. J. S. Robertson of Barton, has seen them twice at his place, which is about two miles within the Colorado line. Though this species has for years been moving westward, its further extension will be slow and probably not for any great distance. From Ogallala westward for the next hundred and fifty miles the native country is entirely unsuited to their wants, and the only grain fields occur as isolated patches of small extent under the ditches near the South Platte River. There is little to induce the birds to enter this country, and any that did migrate there would soon be exterminated by hunters and coyotes.

Page 71. 308b. **Pediocætes phasianellus campestris.** PRAIRIE SHARP-TAILED GROUSE.

Reports from two hunting parties that visited northwestern Colorado during the fall of 1897 indicate that in some of the wilder regions these birds are still not uncommon. The only specimen that was brought back was typical *campestris*.

Page 71. Add. 000. **Phasianus torquatus.** RING PHEASANT.

Resident; not common and local. This is the commonly called Mongolian Pheasant that has been introduced south of Denver. Mr. Aiken also saw one in the fall of 1897 near Colorado Springs, though this may have been a bird escaped from captivity.

Page 72. 312. **Columba fasciata.** BAND-TAILED PIGEON.

Quite common and breeds in the mountains near Glenwood Springs, showing that its regular extension west of the range is rather further to the north than on the eastern slope.

Page 73. 319. **Melopelia leucoptera.** WHITE-WINGED DOVE.

Under a late date, Mr. E. L. Berthoud writes concerning his record of this species, "Besides the record of 1869, when we shot one or two, I have seen two small flocks since. There was no mistaking this bird."

Page 73. 327. **Elanoides forficatus.** SWALLOW-TAILED KITE.

In August, 1877, two were brought in the flesh to Mr. C. E. Aiken, one had been shot at Colorado Springs and the other at Manitou Park. One was also shot in August, 1883. These were probably all wanderers that had nested outside of Colorado.

Page 73. 329. **Ictinia mississippiensis.** MISSISSIPPI KITE.

Mr. C. E. Aiken has seen one near Colorado Springs.

Page 76. 356. **Falco peregrinus anatum.** DUCK HAWK.

According to Mr. C. E. Aiken a pair nested for five consecutive years in the Garden of the Gods. He secured one of the old birds in 1885.

Page 77. 364. **Pandion haliaëtus carolinensis.** AMERICAN OSPREY.

They are very common spring and summer at Sweet Water Lake in the mountains east of Glenwood Springs at 8,000 feet, writes Mr. L. D. Gilmore.

Page 77. 365. **Strix pratincola.** AMERICAN BARN OWL.

Three more records near Pueblo are added by Mr. W. F Doertenbach — a fine male killed and mounted by him August 12, 1897, one other in 1889 and a third in 1891.

Page 77. Add. 371. **Nyctala tengmalmi richardsoni.** RICHARDSON'S OWL.

Winter visitant; rare. The only certain record for Colorado is the male taken by Mr. H. C. Lee Meyer at Crested Butte, October 14, 1896. Through the courtesy of Mr. W. F. Doertenbach of Pueblo, the present writer had the pleasure a few days ago of examining this specimen and there can be no question of the identification.

Page 78. 373e. **Megascops asio maxwelliæ.** ROCKY MOUNTAIN SCREECH OWL.

Mr. Aiken writes that this form occurs at Colorado Springs in winter, but not in summer.

Page 78. 373g. **Megascops asio aikeni.** AIKEN'S SCREECH OWL.

According to Mr. Aiken, none of these Owls are found at Colorado Springs in the winter, indicating that this and the preceding species perform a slight migration.

Page 78. 374. **Megascops flammeola.** FLAMMULATED SCREECH OWL.

The seventh, eighth and ninth specimens taken in the United States outside of Colorado are noted by Mr. Manly Hardy, Brewer, Me., who writes: "I have an adult female and a fully grown young Flammulated Screech Owl taken in 1883 at Santa Fé, New Mexico, by Chas. H. Marsh. Also an adult male taken in the Huachuca Mountains of Arizona by a Mr. Lusk, August 24, 1895."

The twelfth and thirteenth specimens for Colorado are recorded by Capt. D. B. Ingraham, who took a set of two fresh eggs at Beulah, May 27, 1897, and on May 29 a set of three eggs slightly incubated. The females were secured in both cases and identified by Prof. Allen. (Auk, XIV. 1897, p. 403). A female Flammulated Owl was shot by Mr. W. A. Sprague near Boulder, September 22, 1897. The skin was sent to the present writer for identification. This makes the fourteenth specimen for Colorado and the twenty-third for the United States. There are six known cases of breeding, all in Colorado.

Page 79. 375a. **Bubo virginianus pallescens.** WESTERN HORNED OWL.

This is the present recognized name for this variety instead of *subarcticus* (Stone., Am. Nat. XXXI. 1897, p. 236). To settle the exact name of the common Horned Owl of Colorado, Mr. C. E. Aiken lately sent eight specimens to the Smithsonian Institution. They embraced dark and paler examples from both the plains and mountain. They were pronounced by Mr. Ridgway as all of them *pallescens*, saying, "some of them are darker than the normal average style and incline toward *saturatus*, in fact they may be fairly considered intermediate between the two, though still nearer *pallescens* than *saturatus*."

Page 80. 376. **Nyctea nyctea.** SNOWY OWL.

Two specimens shot near Colorado Springs and reported by Mr. Aiken represent about the extreme southern range of the species in Colorado.

Page 81. 379. **Glaucidium gnoma.** PYGMY OWL.

Mr. Aiken adds three records to those previously published; one on the plains at Pueblo November 1, 1871; one in the win-

ter of 1877-8 on Cheyenne Mountain, and one breeding in 1884 at Ute Pass.

Page 81. 382. **Conurus carolinensis.** CAROLINA PAROQUET.

The record of this species made by Pike in 1807 on the Arkansas River (1895 Edition by Dr. Coues, Vol. II. p. 474) is the earliest allusion to this species in Colorado, but as Pike does not mention it by name, only describes it, its proper place in the Colorado list is that already given it (p. 45) as introduced by Dr. Coues in 1877.

Page 83. 396. **Dryobates scalaris bairdi.** TEXAN WOODPECKER.

In the summer of 1897 Mr. W. P. Lowe saw a pair in company with young and feels sure that they were reared in St. Charles Cañon, Pueblo County. He saw a pair of old birds at the same place in 1896.

Page 84. 408. **Melanerpes torquatus.** LEWIS'S WOODPECKER.

Fresh eggs have been found by Mr. N. R. Christie at Rouse Junction, in southern Colorado, as early as the middle of May.

Page 85. 412. **Colaptes auratus.** FLICKER.

Noted by Evermann and Jenkins in the Arkansas Valley in Colorado. (*O. & O., XIII.* 1888, *p. 66.*)

Page 85. 413. **Colaptes cafer.** RED-SHAFTED FLICKER.

Some early eggs were found by Mr. W. A. Sprague at Magnolia, altitude 7,500 feet, on May 17, 1896, and May 20, 1897.

Page 85. 418a. **Phalænoptilus nuttallii nitidus.** FROSTED POOR-WILL.

Two specimens taken by Mr. Aiken at Colorado Springs have been identified as belonging to this variety and thus extending its range to the eastern foothills.

Page 86. No. 455 is a misprint for No. 425.

Page 86. 433. **Selasphorus rufus.** RUFOUS HUMMINGBIRD.

To the records east of the range add one taken about the middle of July, 1897, by Mr. Aiken, at Ramah, on the Divide south of Denver, at about 8,000 feet. The known northward range of this species has been greatly extended by the capture of a specimen July 24, 1897, in Carbon County, Wyo., a hundred and fifty miles northwest of Laramie City.

Page 87. Add. 436. **Stellula calliope.** CALLIOPE HUMMINGBIRD.

Summer visitant; rare or accidental. An adult male was found dead July 25, 1897, in Cheyenne Cañon, near Colorado Springs. The skin is now in the collection of Mr. C. E. Aiken.

Page 87. 447. **Tyrannus verticalis.** ARKANSAS KINGBIRD.

448. **Tyrannus vociferans.** CASSIN'S KINGBIRD.

During a collecting trip on the Divide south of Denver, in 1897, Mr. Aiken took careful notes of the relative abundance of these two species in the breeding season, at Ramah, altitude 8,000 feet. In quite a small area he found about a hundred and fifty pairs of the Arkansas Kingbird and only about twenty-five pairs of Cassin's.

Page 89. 474a. **Otocoris alpestris leucolæma.** PALLID HORNED LARK.

The determinations of Mr. Ridgway, mentioned below, make it probable that most of the winter birds of northern Colorado should be referred to *arenicola* instead of *leucolæma*.

Page 89. 474c. **Otocoris alpestris arenicola.** DESERT HORNED LARK.

A series of ten Horned Larks from Colorado were sent by Mr. Aiken to Washington. They embraced winter and summer specimens selected from a large number to show all phases of plumage, some even having the throat white without trace of yellow. They are all referred by Mr. Ridgway to *arenicola*.

Page 91. 487. **Corvus cryptoleucus.** WHITE-NECKED RAVEN.

A nest with eggs was found by Mr. Aiken in May, 1878, on Horse Creek, seventy-five miles east of Colorado Springs.

Page 92. 491. **Nucifraga columbiana.** CLARKE'S NUTCRACKER.

The first sentence should read: "The first eggs known to science from Colorado, etc." Maj. Bendire had previously taken the nest and eggs in Oregon.

Page 93. 494. **Dolichonyx oryzivorus.** BOBOLINK.

Several more records can be added to the five previously known. Mr. H. G. Smith saw a male in a garden in the city of Denver in June several years ago. Mr. C. E. Aiken took one in fall plumage at Colorado Springs September 5, 1897. There is a mounted bird at Cheyenne taken by Mr. F. Bond, who writes: "The Bobolink is not uncommon with us. I have taken them yearly for some years; sometimes within the city limits."

Page 94. 506. **Icterus spurius.** ORCHARD ORIOLE.

Three were seen by Mr. Aiken in Beaver Creek Valley, Fremont County, in May, 1875.

Page 95. 507. **Icterus galbula.** BALTIMORE ORIOLE.

Mr. E. L. Berthoud writes that he has seen the Baltimore Oriole occasionally at Golden.

Page 95. 514a. **Coccothraustes vespertinus montanus.** WESTERN EVENING GROSBEAK.

Five of these birds were seen by Mr. P. L. Jones at Beulah, August 3, 1897. They remained in that vicinity for over two weeks, being seen almost every day. As Mr. Jones has also seen them late in May, it is almost certain that they breed in Colorado.

Page 97. 524. **Leucosticte tephrocotis.** GRAY-CROWNED LEUCOSTICTE.

According to Mr. Aiken this species is somewhat irregular in its appearance at Colorado Springs, but winters almost every year in considerable numbers and some years becomes abundant. A male and a female were taken by Mr. W. A. Sprague on November 27, 1895, at Magnolia at 7,500 feet.

Page 98. 525. **Leucosticte atrata.** BLACK LEUCOSTICTE.

A few days ago the present writer had the pleasure of examining Mr. C. E. Aiken's large collection of the *Leucosticte*. Mr. Aiken probably has more specimens of *atrata* than all other collections together. They have been taken near Colorado Springs during the winter season and as late as April 4. They have been taken during the winters 1875, 1876, 1877, 1879 and 1883. During the fall of 1894 Mr. Aiken saw them in the Uintah Mountains in Utah near where Dr. F. V. Hayden took his specimen in 1870.

This Hayden specimen has been given the credit of being the first known to science (Ridgway, Bull. Geol. and Geog. Surv. Ter. Second Series No. 2, p. 53). Mr. Aiken however calls attention to the fact that there is an earlier specimen. He says: "It was shot in March, 1870, at Sherman, Wyo., [just over the Colorado line] by J. Denchman and sent by express to Mr. Holden in Chicago, together with about sixty specimens of *L. tephrocotis*—all in the flesh. Mr. Holden and myself examined this specimen carefully on the arrival of the shipment and as it was apparently an immature bird, we concluded that it was the young of *tephrocotis*, though the proba-

bility of its being an example of melanism was entertained. I think this specimen is still in Mr. Holden's collection. On securing my four specimens at Cañon City in April, 1874, I knew they were identical with the Holden bird and was confident that they represented an undescribed race." Mr. Holden has recorded this specimen as follows: "In one specimen, a young male, I think, the plumage is almost black, in fact it is black, except the wings and after half of the body. It is an interesting specimen." (Holden and Aiken, Proc. Bost. Soc. Nat. Hist., XV. 1872, p. 200.)

This specimen was not taken in Colorado and the first specimen for this State is the one already accredited to Mr. Aiken in 1874.

Page 98. Add. 528b. **Acanthis linaria rostrata.** GREATER REDPOLL.

Winter visitant rare or accidental. There is only one Colorado record for this northern species. Mr. W. A. Sprague shot one December 9, 1895, near Magnolia, at an altitude of 7,500 feet. Of this specimen, Mr. Ridgway says that it is not typical but near enough to be called this variety.

Page 99. **Passer domesticus.** EUROPEAN HOUSE SPARROW.

A wonderful increase has taken place with these birds during the last twelve months. They reached Fort Collins in the fall of 1896. So that now they occur along the eastern base of the foothills for nearly two hundred miles. Mr. E. L. Berthoud notes a short visit from them a few years ago at Golden, well up in the foothills, but they did not remain and none have since been seen.

Page 100. 534. **Plectrophenax nivalis.** SNOWFLAKE.

A pair were shot by Mr. Aiken at Colorado Springs the winter of 1877-8. This is the most southern record for Colorado.

Page 101. 542b. **Ammodramus sandwichensis alaudinus.** WESTERN SAVANNA SPARROW.

The question having been raised as to whether all of the Savanna Sparrows of Colorado belong to the western race, a large series was submitted by Mr. Aiken to the Smithsonian. They were all pronounced *alaudinus*. Another series sent by the present writer to Prof. Allen received the same identification. Nevertheless Mr. Aiken is quite sure that in the field he can see a difference between the breeding birds and the migrants. The latter is the larger and moves earlier, arriving at Colorado Springs the last of July to the first of August and leaves the first of October.

Page 101. 546a. **Ammodramus savannarum perpallidus.** WESTERN GRASSHOPPER SPARROW.

A large series of this Sparrow submitted to Prof. Allen and Mr. Ridgway are all considered as true *perpallidus*.

Page 103. 558. **Zonotrichia albicollis.** WHITE-THROATED SPARROW.

One taken by Mr. H. W. Nash at Pueblo, October 18, 1893. This is the third record for Colorado.

Page 103. 560. **Spizella socialis.** CHIPPING SPARROW.

The more the Chipping Sparrows of Colorado are investigated the more evident it becomes that the eastern form is far less common in the State than had formerly been supposed. There is need of much more work in the matter on the plains of eastern Colorado, before the distribution of the two varieties can be determined.

Page 104. 566. **Junco aikeni.** WHITE-WINGED JUNCO.

In the fifth line the "5th of October" was a misprint in the original article for the "5th of November." Mr. Aiken writes that the earliest he has seen the birds at Colorado Springs is October 26, 1897.

Page 105. 569. **Junco caniceps.** GRAY-HEADED JUNCO.

At Magnolia, Boulder County, at 7,500 feet, Mr. W. A. Sprague found eggs May 25, 1896, and young birds a week old May 29, 1897. On July 6, 1897, he also found young birds newly hatched showing that two broods are reared in northern Colorado. Mr. Aiken thinks that these Juncos winter in the mountains as far north as Colorado Springs, coming to the plains during storms and returning to the mountains as soon as the weather moderates.

Page 106. 574a. **Amphispiza belli nevadensis.** SAGE SPARROW.

The known northeastern extension of this species has been largely increased by a specimen taken just over the Colorado line in Wyoming, near Cheyenne, by Mr. F. Bond. The specimen is now mounted in his collection. This is apparently the first record east of the Front Range.

Page 107. Add. 584. **Melospiza georgiana.** SWAMP SPARROW.

Summer visitant; rare or accidental. Only one instance known, seen by Mr. Aiken, at Colorado Springs, the latter part of August, 1897. Regularly comes west only to the plains, but has been once taken in Utah.

Page 107. 585c. **Passerella iliaca schistacea.** SLATE-COLORED SPARROW.

An adult male was taken in July, 1889, at Florissant, by Dr. J. L. Goodale, now of Boston, Mass The specimen is still in his collection, but its capture has not before been recorded. Mr. David Bruce of Brockport, N. Y., took one on the Grand River, near Glenwood Springs, during June, 1897. The bird was seen several times and was evidently breeding.

The above records are the only unquestionable ones that this species has for Colorado. They confirm the previously accepted belief that the bird is a summer resident in Colorado.

Page 108. 593. **Cardinalis cardinalis.** CARDINAL.

A second record for Colorado is that of Mr. H. W. Nash who saw one at Pueblo about November 28, 1895.

Page 108. Add. 595. **Habia ludoviciana.** ROSE-BREASTED GROSBEAK.

Summer resident; rare, if not accidental. It is with some hesitation that the present species is given a place in the Colorado list and yet after most careful investigation there seems scant possibility of error. In the summer of 1894 a pair nested near the house of Mrs. J. W. Bacon, Longmont. The male was several times seen at a distance of less than twenty-five feet and the rose color distinctly noted. Later the same bird was seen on the lawn feeding the newly fledged young. One of the latter was caught.

Page 109. 597a. **Guiraca cærulea eurhyncha.** WESTERN BLUE GROSBEAK.

Not an uncommon bird as far north as Pueblo and breeds in the foothills as far up as Beulah where Mr. P. L. Jones took four nests in 1897. Farther north at Colorado Springs it still occurs regularly though not common. North of there, the only record is that of one taken by Mr. H. G. Smith east of Morrison.

Page 109. 604. **Spiza americana.** DICKCISSEL.

One taken by Mr. C. E. Aiken at Colorado Springs August 29, 1897.

Page 110. 607. **Piranga ludoviciana.** LOUISIANA TANAGER.

There are no records of this bird breeding in Colorado below 6,000 feet, but in northeastern Wyoming at Sundance, Prof. Knight found it in 1897 breeding at 4,500 feet.

Page 110. 608. **Piranga erythromelas.** SCARLET TANAGER.

Migratory; rare. The brackets can now be removed from this species and it be entered as a Colorado bird. A few weeks

ago the present writer saw at Glenwood Springs two mounted males that were taken near Newcastle the spring of 1892. Mr. E. L. Berthoud writes that he took one on Bear Creek near Golden in 1867 and also saw one in the Del Norte Valley, in September, 1883. That it should appear at the edge of the the plains is not wonderful, but the two records west of the range were entirely unexpected.

Page 112. 624. **Vireo olivaceus.** RED-EYED VIREO.

To previous records add one seen by H. G. Smith at Denver May 22, 1892.

Page 112. 629a. **Vireo solitarius cassinii.** CASSIN'S VIREO.

One was taken by Mr. W. F. Doertenbach, near Pueblo, September 6, 1897. Two were seen and one secured.

Page 113. Add. [645a. **Helminthophila ruficapilla gutturalis.** CALAVERAS WARBLER.

One adult and one young-of-the-year were taken on Teepee Creek, Carbon County, Wyo., July 19, 1897, and one young-of-the-year near Reed's Ranch, Albany County, Wyo., August 3, 1897. These specimens are now in the museum of the State University at Laramie City. All of these birds were taken near the Colorado line, making it practically certain that this species will yet be found in western Colorado. It is certain that these birds are *ruficapilla* of either the eastern or western form, but the above reference to the western form is given merely on geographical grounds. When the present writer examined the specimens he had no means of determining the exact variety.]

Page 113. 647. **Helminthophila peregrina.** TENNESSEE WARBLER.

Summer resident; rare. This species is brought among the breeders of Colorado on the strength of two nests found by Mr. C. E. Aiken, one in Colorado Springs and one near there. Mr. F. Bond writes that he has seen these birds several times at Cheyenne during migration.

Page 115. 657. **Dendroica maculosa.** MAGNOLIA WARBLER.

One taken by Mr. H. G. Smith, near Denver, May 17, 1888.

Page 116. 665. **Dendroica nigrescens.** BLACK-THROATED GRAY WARBLER.

According to Mr. Aiken this Warbler is not an uncommon breeder in the piñon hills north and east of Cañon City. It arrives early in May.

Page 116. Add. 672. **Dendroica palmarum.** PALM WARBLER.

Migratory; rare or accidental. One was seen by Mr. H. G. Smith in Denver, June 20, 1891. The specimen was not

secured, but was seen so close at hand and so carefully identified that there is undoubtedly no mistake in the matter. This is an eastern species and comes regularly so near to Colorado that it is strange there are no more records of its occurrence here.

Page 116. 675a. **Seiurus noveboracensis notabilis.** GRINNELL'S WATER-THRUSH.

Several seen by Mr. C. E. Aiken at Cañon City in May, 1873.

Page 118. 701. **Cinclus mexicanus.** AMERICAN DIPPER.

The Dipper nested in 1897 at Coburn's mill west of Boulder at 7,000 feet, according to Mr. W. A. Sprague, and probably on Middle Boulder Creek as low as 6,500 feet.

Up to December 15, 1897, Mr. L. D. Gilmore saw one frequently on the headwaters of Clear Creek at 10,500 feet. On October 3, 1897, he saw one just above timber line near Berthoud's Pass at 11,500 feet.

Page 120. 708. **Harporhynchus bendirei.** BENDIRE'S THRASHER.

Summer resident; rare and local. Mr. N. R. Christie writes that it breeds at Rouse Junction, in south central Colorado, at 6,000 feet. On June 6, 1896, he found two sets of three eggs each; June 2, a set of two eggs almost hatched; June 13, nest and four young. In 1897 one pair was noticed in May but no nests found.

Page 120. 719b. **Thryothorus bewickii leucogaster.** BAIRD'S WREN.

These Wrens are found by Mr. Christie as not uncommon at Rouse Junction, nesting about the first of June. Mr. Aiken shot one at Colorado Springs, May 1, 1879.

Page 122. 733a. **Parus inornatus griseus.** GRAY TITMOUSE.

Found by Mr. Aiken as a common winter resident in the foothills, northeast of Cañon City, where a few remain to breed.

Page 124. 751. **Polioptila cærulea.** BLUE-GRAY GNATCATCHER.

Mr. H. G. Smith has seen one at Denver.

Page 124. 754. **Myadestes townsendii.** TOWNSEND'S SOLITAIRE.

A nest with four eggs heavily incubated was taken by the present writer July 25, 1897, in Estes Park at 8,500 feet.

Page 125. 759. **Turdus aonalaschkæ.** DWARF HERMIT THRUSH.

One was taken by Mr. W. A. Sprague at Magnolia, altitude 7,500 feet, October 6, 1895.

Page 126. 766. **Sialia sialis.** BLUEBIRD.

Mr. H. W. Nash took one at Pueblo April 5, 1883.

INDEX.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 45.

THE LOSS OF WATER FROM RESERVOIRS BY SEEPAGE AND EVAPORATION.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MAY, 1898.

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THE LOSS OF WATER FROM RESERVOIRS BY SEEPAGE AND EVAPORATION.

By L. G. CARPENTER.

For convenience of reference the principal paragraphs are numbered. A summary and conclusions are given on the last pages of the bulletin.

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§ 1. This bulletin was intended to give the results of a series of observations made to determine the loss from seepage on reservoirs near Fort Collins, during the winters of 1895-6 and 1896-7, and to give such of the related observations on evaporation as were necessary to throw light on the measurements from the lakes. As the losses from seepage were less than expected, the losses from

evaporation were correspondingly more important. Without intending, or desiring, in this place, to enter upon a discussion of the mass of evaporation observations, this fact has led to a fuller statement of the observations of evaporation than were at first thought necessary or desirable.

§ 2. The loss from the lakes may be due to evaporation from the water surface, and seepage or filtration through the dam and bottom of the reservoir. The leakage through imperfectly fitting gates can be prevented or remedied by better construction. Gain may come from rainfall on the lake, the drainage from the water shed tributary to the lake and the seepage from irrigated lands above the lakes. The aggregate of these gains and losses is desired by the companies as much, or more, than a knowledge of each, but the aggregate can best be told when a knowlege of the amount of loss or gain from each cause is determined. The losses from seepage in many cases deserve most attention, as they may vary between wide limits, and to some extent are preventible. The amount of loss from evaporation may be estimated with considerable certainty. The loss from seepage is more uncertain, as it must vary with the conditions of each basin, and the amount is peculiar to that particular site. Its determination is surrounded with difficulty, and requires accessory investigations, so that attempts to determine the loss by seepage from reservoirs seem not to have been made, or if so, I have been unable to find any records of the attempt or of the results. But while evaporation depends upon various circumstances some of which can be controlled, the amount of evaporation cannot be materially modified at any practicable cost.

§ 3. Generally the scarcity of sites for reservoirs makes the selection depend on their availability, nevertheless the possibility of an undue loss from seepage needs to be borne in mind in making the selection. In most of the sites found in Colorado, the strata form a natural basin from which the loss by seepage is small. There are places in which the strata of rock incline both ways from the reservoir, an anticlinal in the term of the geologist. This condition or when the strata dip in one direction from the site should be avoided, although when the rocks are deeply covered with soil undesirable effects may be small. I have seen reservoirs in Algeria with the strata inclining from the reservoir, where all the exposed rock has been cemented in order to prevent the loss of water through the strata. With a bottom of sand, the loss may be large for a time, but the action rapidly grows less after the sand layers are once saturated.

EVAPORATION.

§ 4. The general conditions of evaporation are well known. The amount of evaporation depends upon the temperature of the

water, upon the dryness of the air (not directly upon the temperature of the air), upon the wind. The wind brings fresh, unsaturated air in contact with the water surface and gives opportunity for more vapor to be absorbed. Unless the temperature of the water surface is warmer than the dew point of the air, evaporation cannot proceed; if lower, condensation may take place. The wind also causes waves and increases the area subject to evaporation.

§ 5. The temperature of the water affects the evaporation much more than is usually realized. A shallow lake evaporates faster than a deep one, because its temperature is higher. Likewise the evaporation from the shallow parts of a lake is greater than from the deep portions. I have often found the temperature of the water in the shallow areas much higher than at the deep places. The temperature of the water, and the wind exposure, may differ so much between bodies of water in the same neighborhood that a general statement must be accepted with reserve. It is entirely possible for two tanks side by side to have very different losses from evaporation. In the evaporation tank, which has now been maintained for eleven years, the loss from evaporation averages 41 inches per annum. From lakes during the summer months the evaporation has been found to be as much as twice that from the tanks, an increase of temperature of ten degrees, or enough to change the temperature from 70° to 80°, may be sufficient to double the amount.

§ 6. Evaporation proceeds from ice, but at a diminished rate. When our tanks are frozen they show a loss of from 1 to 1½ inches per month, solely from the frozen surface.

The evaporation at night, contrary to common opinion, is almost the same as during the day, and this is nearer equality as the body of water is larger. Even in our tanks, the evaporation during the nights of a month is often found to be more than during the days for the same period.

THE LOSS FROM SEEPAGE.

§ 7. For two winters observations were made to determine the loss from reservoirs by seepage. In many cases water runs into the reservoirs until late in the fall and the filling begins early in the spring, hence the period during which the losses can be found without measurements of inflow and outflow is short. Nearly a dozen reservoirs were visited. Bench marks were established, and levels run to the surface of the water. Some of those selected were filled during the winter, and the record was of no value. Perhaps half a dozen gave some basis for estimating the loss.

Most of the reservoirs under observation are natural basins situated within twelve miles of Fort Collins, and at an elevation from 5,000 to 5,500 feet above sea level. The sites have been ponds in wet

weather, and the extreme bottom is covered with thin silt, which when soaked is nearly impervious to water. On the sloping sides the soil consists of a gravelly loam or sandy clay, but lacking the natural impervious coating.

METHOD OF OBSERVATION.

§ 8. At the first visit of the season, some well marked and permanent object was selected as a reference point. If none was convenient, a stake was driven where it would remain undisturbed through the winter; the top was used as a reference point. The elevation of the water surface was compared with the height of the top of the stake by an engineer's level. In case of ripples or waves, the observer was instructed to take the mean water level as near as it could be estimated. Any heaping of the water on one side of the lake from wind was not eliminated. Such cause may effect some of the observations, but the effect has been slight, and can affect but few. April 17, 1897, was windy, and the greatest effect is thought to have been on that day. As the reservoirs were filled immediatly thereafter, this was the last observation that could be made, and has been used.

For a portion of the winter the lakes were covered with ice. When this was the case, holes were cut, and the elevation of the water surface taken. In almost no case did the water rise to the surface of the ice.

DESCRIPTION OF THE LAKES.

§ 9. Loomis lake is one and one half miles west of the Agricultural College. It is a shallow natural basin, which by the construction of an embankment on the north side has been converted into a reservoir. The Larimer County Canal No. 2 runs close to the west side of the lake, and for rods the embankment of the canal forms the only separation between the two. The basin is but little below the plain. Trees and brush on the ditch embankment protect the lake to some extent from west winds. The lake may receive water by seepage from lands to the west, principally lands irrigated from the Pleasant Valley and Lake Canal. Any surface drainage is intercepted by the New Mercer and the Larimer Co. No. 2 Canals, with the exception of that from a strip on the south and east covering but a couple of acres. The lake receives the waste water from some of the neighboring farms. The lake showed a gain in the winter of 1895–6, and a loss in the winter of 1896–7. It is probable that some water wasted into the lake the first winter.

No Name lake is a lake of about an acre, to the east of the reservoir of the Larimer and Weld Reservoir Company, about two miles north of Fort Collins. It has but a small drainage area. It is filled from the Larimer County Canal.

The Rocky Ridge reservoir is situated several miles farther north, on the east side of the Larimer County Canal, which here passes on a ridge on the west and south side of the lake. To the east of the lake is a cliff of sandstone several hundred feet high. The outlet of the reservoir is by a short tunnel under the canal, through a ridge to the west of the lake. The reservoir was being filled during the second winter of observation, so that a record was not taken.

The North Poudre Canal reservoirs, of which three were observed in the winter of 1895–6 and four in the winter of 1896–7, are natural basins, most of which have an embankment thrown up on one side. These lakes are of considerable size, some having an area of several hundred acres. Before they were converted into reservoirs, they held storm waters and collected some flood water, so that the bottoms were covered with silt. There are no trees to shield them from the wind.

Rigden lake is a natural basin one mile east and two miles south of the Agricultural College. It has neither inlet nor outlet. Some seepage shows on the inclined sides of the basin during the summer season, and the ground is soft in places. The lake collects the waste and seepage waters from irrigated land to the west. The nearest ditch that is more than a small lateral, is over a mile away. The lake is not fully exposed to the wind, being below the surface of the plain, and protected by a grove of cottonwoods a few rods to the west, and another a short distance to the east.

Warren lake lies a mile and one half south of Rigden lake, and is used as a reservoir. It has an embankment on the northeast side. Some seepage water enters at the west side, and also waste water from irrigation. Observations on evaporation were carried on in this lake for several years. The observations on loss by seepage were of no result, as the company found it convenient to fill the lake, and the filling, together with the seepage inflow, made the observations inconclusive.

TABLE I.—SUMMARY OF OBSERVATIONS ON LOSSES FROM RESERVOIRS.

1896.

Name of Lake.	Period.	No. of days.	Net loss—inches.	Rain during period—inches.	Total loss—evaporation and seepage—inches.	NOTES.
Rigden Lake	Feb. 18—Mar. 20.	31	3.24	1.21	4.45	Feb. 18, little ice in lake. Water 46° 4 p. m. No water running in.
	Mar. 20—April 11.	22	3.36	.67	4.03	Mar. 20, no ice. April 11, water 63° at 11 a. m.
Loomis Lake	Feb. 18—Mar. 20.	31	3.40 g	1.21	2.19 g	Feb. 18, no water running in.
	Mar. 20—April 11.	30	8.84 g	.67	8.17 g	Mar. 20 no ice. April 11, water running in adjacent canal; water in canal April 5.
No Name Lake	Feb. 19—Mar. 12. Mar. 12—April 14.	21 33	2.04 4.08	.66 1.22	2.70 5.30	Small drainage area. April 14, temperature 62° at 9 a. m. Soil moist for 4 in.
Rocky Ridge Lake	Feb. 20—Mar. 12. Mar 12—April 14.	21 33	.... 2.65	.66 1.22	.... 3.87	Filled in this interval. March 12, ice mostly gone. April 14, temperature water 54° at 10 a. m. Waves cause change of level of 1/8 in. during measurement. Ground moist 3 in. deep.
Reservoir No. 1, North Poudre Canal	Feb. 20—Mar. 12. Mar. 12—April 14.	21 34	1.33 .76	.66 1.22	1.99 1.98	Drainage area about 2 square miles. April 14, temperature water 59° at 11 a. m. Level affected by waves.
Reservoir No. 2, North Poudre Canal (Demmel Lake)	Feb. 20—Mar. 12. Mar. 12—April 14. Dec. 5, '95—April 10.	21 34 127	1.64 3.31 4.00	.66 1.22 2.19	2.30 4.56 6.19	Drainage of about 2 square miles. April 14, temperature 53° at 12 m. From record of Mr. E. J. Gregory, Supt.
Reservoir No. 3, North Poudre Canal (Tenney Lake).	Feb. 20—Mar. 12. Dec. 5, '95—April 10.	21 127	9.90 4.00	.66 2.19	10.56 6.19	April 14, water running in lake. From Mr. Gregory, Supt.
Reservoir No. 4, North Poudre Canal	Dec. 5, '95—April 10.	127	6.00	2.19	8.19	From Mr. Gregory, Supt.

TABLE II.—SUMMARY OF OBSERVATIONS ON LOSSES FROM RESERVOIRS.

1897.

NAME OF LAKE.	Period.	No. of days.	Net loss—inches.	Rain during period—inches.	Total loss—evaporation and seepage—inches.	NOTES.
Loomis Lake	Feb. 3—Mar. 6.	31	.64	.72	1.36	Feb. 3, ice covered. Little snow on ice. Ice 5 in. thick.
	Mar. 6—Mar. 17.	11	.96	.08	1.04	March 6, ice covered.
	Mar. 17—April 17.	31	.92	2.90	3.82	March 17, most ice gone. Sides of basin wet from frost coming out of ground.
No Name Lake	Feb. 2—Mar. 5.	31	.49 g	.72	.23	Ice 5 in. thick. About 1 in. snow on ice. Water rises same height as ice.
	Mar. 5—Mar. 17.	12	.70	.08	.78	March 5, ice 6 in. thick. No appearance of water having run in. Little crusted snow on ice—about ½ or ¾ in. March 12, some open water.
	Mar. 17—April 17.	31	1.54	2.90	4.44	April 12, windy, poor measurement and not used. April 17, measurement all right.
Reservoir No. 1, North Poudre Canal	Feb. 2—Mar. 5.	31	.62	.72	1.34	Feb. 2, ice 6 in. thick. Some snow. Water rises above ice in hole.
	Mar. 5—Mar. 17.	12	.96 g	.08	.88 g	March 5, little open water. Ice 6 in. thick. No appearance of water having run in.
	Mar. 17—April 12.	26	4.88 g	2.74	2.14 g	March 17, snow all gone. April 12, heavy wind from northwest.
Reservoir No. 2, North Poudre Canal (Demmel Lake.)	Feb. 2—Mar. 5.	31	.43	.72	1.15	Feb. 2, thin layer of snow on some parts of ice.
	Mar. 5—Mar. 17.	12	.48	.08	.56	March 5, ice 8 in. thick. Very little open water. Think no water entering from any source.
	Mar. 17—April 12.	26	3.20 g	2.74	.46 g	March 17, considerable open water. Drove stake to level of water for measurement. April 12, windy, measure uncertain.
Reservoir No. 3, North Poudre Canal	Feb. 2—Mar. 5.	31	.18	.72	.90	Feb. 2, strip open water near edge.
	Mar. 5—Mar. 17.	12	....	....	....	March 17, filling lake. Small amount running out of lake.
Reservoir No. 4, North Poudre Canal	Feb. 2—Mar. 5.	31	.41	.72	1.13	Feb. 2, ice about 5 in. thick. About 1 in. snow on ice. Water rises same level as ice.
	Mar. 5—Mar. 17.	12	.48	.08	.56	March 5, some crusted snow on ice.
	Mar. 17—April 12.	26	3.82 g	2.74	1.08 g	March 17, snow gone. April 12, ground around lake moist and muddy. Small amount of water running in from snowbank.

§ 10. The total loss given in Table 2 is the combined loss from seepage and evaporation. The records, given later in the bulletin, form the basis of the estimated evaporation given in the column so headed in the following table. The difference, unaccounted for by evaporation, is the loss due to filtration or seepage. In forming this table, only those cases where a loss was shown have been taken. It is noticeable that there are many cases in which the total loss was less than the amount of evaporation; in other words, the reservoirs were gaining water from the run-off of the water sheds running into the lake, or from seepage entering the lakes, or perhaps, in a few cases, from water in the supplying ditches, which had been reported dry. This is shown in the following table:

TABLE III.—LOSSES DUE TO SEEPAGE ALONE.

NAME OF LAKE.	Total Loss—Inches.	Evaporation (estimated)—Inches.	Remainder (seepage)—Inches.	No. Days.	Seepage per Day—Inches	Per Year, at Same Rate.
Rigden Lake, 1896	4.45	2.39	2.06	31	.067	24.25
	4.03	2.58	1.45	22	.066	24 06
Loomis Lake, 1897	1.36	2 43	1.07 gain	31	Gain	Gain
	1.04	.85	.19	11	.017	6.30
	3.82	2.97	.85	31	.027	10.01
No Name Lake, 1896	2.70	1.70	1.00	21	.048	17.38
	5.30	3.66	1.64	33	.050	18.16
	.23	2.43	2.20 gain	31	Gain	Gain
	.78	.93	.15 gain	12	Gain	Gain
1897	4.44	2.97	1.47	31	.0475	17.31
Rocky Ridge Lake	3.87	3.66	.21	33	.006	2.32
Res. No. 2, North Poudre Canal 1896	1.99	1.63	.36	21	.016	6.26
	1.98	3.66	1.68 gain	34	Gain	Gain
1897	1.34	2.20	.86 gain	31	Gain	Gain
Demmel Lake, 1896	2 30	1.63	.67	21	.032	13.21
	4.56	3.66	.90	34	.0265	9.67
1897	1.15	2.20	1.05 gain	31	Gain	....
	.56	.93	.37 gain	12	Gain	....
Res. No. 3, North Poudre Canal. 1896	10.56	1.63	8.93	21	.42	155.00
1897	.90 gain	....	....	....	....	....
Res. No. 4, North Poudre Canal, 1897	1.13	2.43	1.30 gain	....	Gain	....
	.56	.93	37 gain	....	Gain	....
	1.08 gain	2.97	4.05 gain	....	....	....
For the whole winter, from the records of the Canal company, there must have been gain from inflow.						
Demmel Lake	6.19	10.26	4.07 gain	127	Gain	....
Res. No. 3, North Poudre Canal	6.19	10.26	4.07 gain	127	Gain	....
Res. No. 4, North Poudre Canal	8.19	10.26	2.07 gain	127	Gain	....

§ 11. It appears that the leakage from these particular reservoirs is very small. After allowing for evaporation, we find that several lakes must have gained water from outside sources, either by some

water coming through the supply ditches, or from the water sheds. The three lakes, Rigden lake, Loomis lake and No Name lake, where the loss is most evident, are cases where the water sheds are small. In the other cases, it was not thought that water could have come from the water shed, but it may be possible.

§ 12. The loss from seepage during the months the lakes were measured, is evidently small. During the remainder of the year the loss will not be much more rapid, but the greater depth of water usually in spring increases the rate. When the lakes are nearly full, the water then covers some ground less completely protected by silt, but in the course of repeated fillings the whole lake bottom will reach much the same condition.

§ 13. In the Rigden lake, the loss from seepage appears to be about 2 feet per year; in the case of the No Name lake not quite so much; in reservoir No. 2, during the period when gain was not noticed, at the rate of 13 feet per year. The loss from the last lake is looked upon with doubt, but no cause other than seepage has been established.

§ 14. As a whole, the losses from the lakes under observation have been small; less than the evaporation, and less than expected. In some other places that have not been subjected to careful observations, the loss has been much greater than found in these reservoirs. Numerous small reservoirs known to the writer have been abandoned for storage purposes, because the loss was so great. In the southern part of the state, one instance was found where a depth of 27 feet is reported to have disappeared between October and the following March. Yet in these cases much of the loss has doubtless been due to filling the adjacent subsoil, as well as to seepage proper.

§ 15. In most of such cases, though the loss is so large at first, it may grow less with succeeding years after the adjacent subsoil is once filled. This may be expected to be the case where there are extensive beds of sand under and surrounding the reservoir. These beds absorb about one third of their volume of water, and continue to absorb as long as there are connected bodies of sand into which it can flow, or other outlets. Where the reservoir is small and the sand bed is large, the amount of water taken up in this way may be large and cause the loss from the lake to be excessive. When, however, the sand is filled, the draft on the lake is much less, the loss is reduced, and the sand holds water with success, as is shown by the lakes in sand hills, or by the holding power of sand embankments.

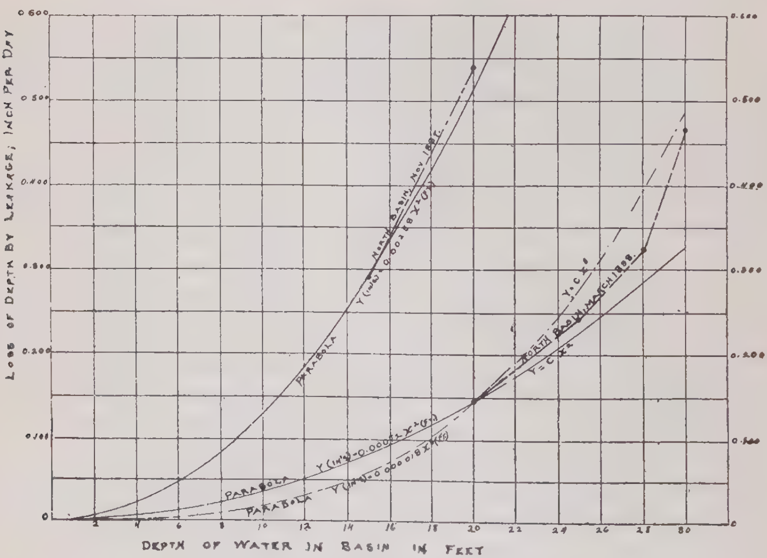
§ 16. In these and other cases the losses may be lessened. For since clay or fine material offers great resistance to the passage of water, only a thin layer of clay or fine sediment is required to greatly diminish the loss of water. One of the most efficient means, there-

fore, of lessening the loss is to change the character of the surface of the lake bottom by the deposit of a thin stratum of fine material. Since flood waters often contain a large percentage of silt, their use and the deposit of such silt, seals the bottom and may make the basin nearly water tight.

The success of the silting process may be expected to be greater with small reservoirs than with large ones. Much of the silt is deposited where the speed of the water is checked, or near the inlet. Near the outlet, where the seepage is usually the greater, less silt is deposited. Yet if the sediment is fine much benefit may be expected by application of this process.

In many cases the water may be made artificially muddy by throwing clay into the inflowing stream, taking pains that it is finely subdivided and is carried in suspension.

§ 17. The loss by seepage from sites, for reasons already mentioned, may be expected to increase with an increase of depth of water in the reservoirs, and to become less with the lapse of time.



Effect of Depth and of Sediment on Loss of Water from Reservoirs.
Observations under J. C. Trautwine, Jr., 1897–98.

The observations reported were during the winter, with the surface of the lakes nearly stationary, and do not show the effect of variation in depth. Several cases, where the loss has been measured from canals, show that the loss increases with the depth of water in the canal, but the loss seems to be greater than shown from theoretical considerations. From Darcy's experiments the writer

deduces an expression for the leakage through embankments, which seems to be proportional to the square root of the cube of the depth. Much of the loss may take place through the bottom, and this would tend to make the leakage increase at a higher rate.

Through the courtesy of John C. Trautwine, Jr., Chief of the Bureau of Water, Philadelphia, I am enabled to quote some recent and valuable observations on one of the reservoirs belonging to that city, and which clearly show the effect of increased depth. The Queen Lane reservoir has considerable trouble on account of leakage, and during the summer of 1897 had been lined with asphalt, the lining being completed August 16th.

The diagram shows the observations at different depths, the two curves representing the losses before and after partially silting the reservoir by pumping into the reservoir water laden with anthracite coal dust.

November, 1897. (Before Silting.)		March, 1898. (After Silting.)	
Depth.	Loss per Day.	Depth.	Loss per Day.
15 feet.	.29 inches.	20 feet.	.15 inches.
20 feet.	.54 inches.	25 feet.	.24 inches.
....	....	28 feet.	.32 inches.
....	....	30 feet.	.46 inches.

These observations show in both cases a more rapid increase in the leakage with depth than would seem to be indicated by the uncertain theory.

That a portion of the rapid increase is due to some change in the conditions is shown by still more recent observations. Under date of April 7th, Mr. Trautwine adds that observations, extending over ten days, with a nearly constant head of about 30 feet, have shown an increase in the daily loss to .55 inch.

Since that date the reservoir has been drawn down to 20 feet, and under date of April 16th, Mr. Trautwine writes that the average daily loss at that depth for eleven days was .28 inch, or about double the amount shown in March.

These interesting facts would seem to show that the conditions remaining the same, the effect of an increase in leakage due to an increase in depth, would be at a much less rapid rate than indicated in the curve shown.

As an explanation of the increase in rate with increased depth, and the continued increase after the depth is reduced, Mr. Trautwine suggests that there may be a velocity of percolation at which the sediment-bearing water ceases to deposit its sediment in the pores and begins to carry away that which has already been deposited, thus permitting an increase under large heads with time.

EVAPORATION.

§ 18. The following table shows the amount of evaporation that has been observed from our standard tank during the past eleven years. The tank is of galvanized iron, three feet square, originally two feet deep, but since 1889, three feet deep. During the summer months, the height of the water is measured by the hook gage to the nearest thousandth of a foot, twice daily. After September, darkness interferes with the observation at 7 p. m. and readings are made only at 7 a. m. After ice forms the tank is undisturbed except at the beginning of the month. The ice is then loosened from the sides of the tank, and the elevation of the water surface, which is then the same as if the floating ice were melted, is measured. Ice sometimes forms of considerable thickness, and punctures in separating it from the sides have caused the loss of the record for several months. The rainfall is measured by standard gages near the tank. The amount given as the evaporation, is the loss from the water surface after allowing for the rainfall, or is the fall of the surface plus the rainfall. The amounts here given are subject to slight corrections, as critical examination may cause the rejection of some days of heavy showers.

TABLE IV.—EVAPORATION FROM WATER SURFACE.

Tank 3x3x3 feet, flush with ground, at Fort Collins, Colorado. Elevation 4,990 feet above sea level: latitude 40° 34', longitude 105°. Amounts are given in inches.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1887........	2.46	3.23	4.60	5.55	5.19	5.75	5.23	4.24	4.12	3.26	1.48	1.60	46.71
1888........	....	....	....	....	4.45	7.70†	7.00†	4.06	3.94	2.17	1.35	.99	.....
1889........	1.08	1 03	2.75	4.06	3.72	4.34	5.20	5.15	5.19	3.28	.62	1.42	37.84
1890........	.86	2.36	3.48	3.50	4.32	5.71	5.44	5.76	3.69	2.71	1.32	1.10	40.25
1891........	1.89†	1.90	2.23	2.24	5.03	4.97	5.72	4.91	4.12	3 62	1.74	.75	39.12
1892........	2 51	2.15‡	2.78	3.58	3.49	4.20	4.69	5.64	5.11	3.33	1.93	1.13	40.54
1893........	p.	1.52*	3.79	5.40	5.12	6.12	6.41	4.73	5.04	3.79	1 05	1.38	.....
1894........	1.14†	1.15†	1.95	4.61	4.66	5.01	5.74	4.88	3.77	3.75	1.64	1.22	39.52
1895........	1.19†	1.19†	p	4.91	4.27	4.13	4.57	4.52	4.06	2.24	1.53	1.68	.....
1896........	2 64	2.25	2.39	4.71	5.91	5.09	5.23	5 80	3.34	2.94	1.62	1.25	43.17
1897........	1.80	2.20	p.	3.33	4.13	4.26	4.64	4.76	3.97	2.88	1.47	.94	.....
Average....	1.73	1.90	3.00	4.19	4.57	5.21	5.44	4.95	4.21	3.09	1.43	1.22	40.94

* Record from part of month.
† Deduced from loss in two months.
‡ From record from February 17.
p. Tank punctured, record lacking.

§ 19. As the temperature of the water is an important factor in the amount of evaporation, the average temperature of the water for the corresponding time is given in Table 5. The temperature given is the mean of the surface temperatures at 7 a. m. and 7 p. m. The maximum and minimum temperatures at the surface have also been taken by self-recording instruments in the water in early spring or late fall. Their record is not so complete and is not given here. The average derived from the 7 a. m. and 7 p. m. observations, as shown by hourly readings, is lower than the average temperature of the tank by about 3.5°. The difference is due to the fact that while

heating, the surface heats rapidly and the lower layers slowly. But in cooling, the whole mass of water cools. The mean of the maximum and minimum temperatures is much closer to the true average temperature.

TABLE V.—MEAN TEMPERATURE OF WATER IN EVAPORATION TANK.

Surface temperatures. Average of 7 a. m. and 7 p. m.

NOTE—The means thus found are less than the true average by 3 or 4 degrees.

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1887	....	....	46.6	49.5	62.3	69.8	73.0	71.5	64.7	59.0	38.9	....
1888	....	....	....	....	....	....	....	....	....	....	...	....
1889	....	....	....	....	....	66.6	72.0	70.5	61.1	52.7	....	....
1890	....	....	....	....	58.9	68.4	75.1	69.9	62.0	49.0	....	....
1891	....	....	....	....	59.4	68.5	74.1	70.5	64.3	50.8	43.1*	....
1892	....	....	....	46.7	54.4	66.9	71.8	70.0	63.2	49.5	....	....
1893	....	....	....	47.0	55.5	68.9	73.9	70.3	63.2	49.0	....	....
1894	....	....	....	49.9	59.8	67.7	73.0	71.8	63.1	51.1	42.8†	....
1895	....	....	....	50.4	59.4	65.6	69.4	70.7	62.8	48.1	....	....
1896	....	....	....	51.1	58.9	69.6	74.1	71.4	63.3	50.9	....	....
1897	....	....	....	48.2	61.4	66.6	70.9	71.4	66.4	51.5	....	....
Average	....	....	....	49.0	58.9	67.9	72.7	70.8	63.4	51.2	41.6	

* First fifteen days.
† First thirteen days.

§ 20. Observations have also been made on the evaporation from reservoirs. Tanks one foot square and eighteen inches high were used and floated by pontoons, and filled with water to 3 or 4 inches from the top. It was intended to maintain the water in the tank at the same level as the water on the outside. In order to break the waves the whole was surrounded by a triangular float of boards, which was anchored so that the angle would face the waves and prevent them washing into the tank. The device was not always completely successful in this respect. At times boys interfered with the tanks. Observations were carried on for several years in Warren's lake, but the interference was so great the observations at that place were abandoned. For the last two years tanks were placed in other lakes, convenient of access, and chosen because the lakes were partially closed to the public and the observations less likely to be interfered with.

§ 21. The lakes used in 1896 and 1897 were Lee's lake, Loomis lake and Claymore lake.

The Lee lake is a small reservoir owned by Dr. E. A. Lee of Fort Collins, and situated about four miles from the College. The lake is shallow and exposed to the wind. Weeds grow freely in the lake, and late in summer form a mass which is difficult to pass through, and greatly hinders the formation of waves. The water has varied from about six to ten feet in depth during the season.

Loomis or Sheldon lake is the same as previously mentioned in the observations on loss from seepage. It is a little over a mile

west of the College. The depth has varied from five to ten feet. This lake is free from weeds.

Claymore lake is situated six miles northwest of the College and close to the ridge of Dakota sandstone which rises immediately from the water on the west side. The lake is a reservoir connected with the Pleasant Valley and Lake Canal. The ridge of sandstone to the west rises at an angle of about 20° and to the height of 400 feet. This ridge interferes with the wind slightly, but because of the downward movement of most of the west winds, it lessens the evaporation very little, if any. This lake is the largest of the three on which observations were taken. The depth of water has varied from 6 to 15 feet. There have been few or no weeds observed, but floating plant life has been abundant.

METHODS OF OBSERVATION.

§ 22. The observations were made weekly in 1896 and semi-weekly in 1897. The distance to the surface of the water in the tank was measured by placing a rule across the top of the tank and measuring down to the surface of the water by a rule graduated to tenths of inches, a rule such as is used in rain gages being used. In order to eliminate the effect of tipping the tank when grasped by the observer, the readings were made at two opposite sides or at the center of the tank. The tanks were filled to two or three inches from the rim and evaporation allowed to proceed until the water had fallen to three to five inches, then again filled from the lake. The measurements cannot be considered as exact, but the error is nearly eliminated in the differences.

RAINFALL.

§ 23. The rainfall as given in the table is that observed at the Agricultural College. The lakes are several miles distant. At times the rainfall is undoubtedly greater or less than that observed at the College. Gages were placed on the floats, but as they could be read only once or twice weekly, the rain record at the College, where the observations are made twice daily, is used instead. The greatest difference is found on days of local thunder storms in July and August, but in only a few cases is there any material difference.

§ 24. The temperature of the surface of the water in the tank, of the surface of the lake, and of the bottom of the lake, was taken. To obtain the temperature at the lake bottom, a sampling instrument was used. This consisted of a brass cylinder with valves at top and bottom, arranged to open as the cylinder descended in the water, and open as it rose. By churning the instrument up and down in the water it was easy to fill it with a sample of water from any desired depth, and bringing the instrument rapidly to the surface, the temperature was immediately taken. It will be noticed that the

bottom of the lake is cooler than the surface, as was to be expected. Table 6 shows the changes during the day at the bottom and surface of Lee lake, the measurements being made at fifteen minute intervals for eight hours. From hourly observations on the smaller evaporation tanks at the College, there is reason to believe that late at night the bottom and surface become of the same temperature, and that at times the bottom is warmer than the surface.

To show the changes in the temperature of a lake during the day the following observations are given. They were made Aug. 6, 1896, on the Lee lake, by Mr. R. E. Trimble:

TABLE VI.

Hour of Observation.	Clouds. in Tenths.	Wind.	Temperature of Water.		
			Tank.	Lake Surface.	Lake Bottom.
9 : 00 a. m.	....	....	71.0	70.2	68.8
9 : 15 a. m.	Few	....	72.0	70.5	68.2
9 : 30 a. m.	Few	Light S. E.	72.0	70.7	68.0
9 : 45 a. m.	Few	Light S E.	72.0	71.2	67.7
10 : 00 a. m.	Few	East.	72.0	71.0	68.0
10 : 15 a. m.	1	....	72.8	71.7	68.8
10 : 30 a. m.	1	Light S. E.	73.3	72.2	69.0
10 : 45 a. m.	2	Light S. E.	74.0	72.9	68.6
11 : 00 a. m.	2	Light S. E.	74.0	73 0	68.5
11 : 15 a. m.	3	Light S. E.	74.0	73.0	68.2
11 : 30 a. m.	3	Light S. E.	73.2	72 9	68.5
11 : 45 a. m.	3	Light S. E.	74.0	73.1	69.1
12 : 00 p. m.	2	Light S. E.	74.2	73.2	69.2
12 : 15 p. m.	2	Light S. E.	74.8	74.0	68.8
12 : 30 p. m.	2	Light S. E.	74.4	74.0	68.8
12 : 45 p. m.	3	Light S. E.	74.5	74.2	69.1
1 : 00 p. m.	4	Light S. E.	74.0	73.9	68.3
1 : 15 p. m.	6	....	74.2	74.2	68.7
1 : 30 p. m.	7	Brisk N.	73.8	73.8	69.1
1 : 45 p. m.	5	Light E.	74.0	74.0	69.4
2 : 00 p. m.	4	Light S.	74.9	74.7	69 8
2 : 15 p. m.	3	W.	75.7	76.0	69.4
2 : 30 p. m.	2	W.	75.5	76.0	69.5
2 : 45 p. m.	2	....	76.0	77.0	70.0
3 : 00 p. m.	1	S. E.	76.6	77.2	69 3
3 : 15 p. m.	2	S. E.	76.2	76.4	69.8
3 : 30 p. m.	2	S. E.	76.2	76.0	69.0
3 : 45 p. m.	2	S. E.	76.0	76.0	69.3
4 : 00 p. m.	1	S. E.	76.0	76.0	68.8
4 : 15 p. m.	2	E.	75.8	76.0	68.2
4 : 30 p. m.	3	None	76.0	76.2	69.0
4 : 45 p. m.	5	N.	75.6	76.7	68.7
5 : 00 p. m.	....	....	75.5	76.8	68.6

The temperature of the surrounding lake was taken to detect whether the tank caused any material change in the temperature of the water in the tank. The difference is slight, and in that respect, the small tanks seem to affect the temperature less than larger tanks. The water in the tank was sometimes warmer than the surrounding lake, occasionally as much as 3° to 5°, but usually less than 1°. The consequence of this increase in temperature is to increase the evaporation, and therefore the amounts measured may be considered slightly greater than evaporation from the lake itself.

§ 25. The wind record is from the anemometer at the Experiment Station of the Agricultural College. The anemometer at that point is exposed on a tower sixty feet from the ground, but with trees, not in all directions, at a moderate distance. The supposition that this record represents the wind at the lakes is subject to the same uncertainties as the similar use of the rain record. The error cannot be great. In the present discussion the wind is not used in the comparison, but is given to exhibit the conditions. The effect of the wind is to increase the amount of evaporation by bringing unsaturated air in contact with the water, and to give opportunity for the diffusion of the water vapor. From the working formula derived from the observations in 1889, each mile of wind increased the evaporation by about 2 per cent. Mr. Fitzgerald's experiments at Boston, indicate an increase of 2 per cent for each mile of wind. The amounts are to be taken subject to investigations since made. A reduction of the observations made at this place during the past ten years should give a more satisfactory and useful formula than that mentioned in the Annual Report of the Experiment Station for 1891. High winds may affect the record by blowing spray into the tank, notwithstanding the protecting shelter. The greatest velocity between the different observations is given. Heavy rainfalls may introduce uncertainties also.

The observations on Claymore lake for three months in the summer of 1897 have not been used, because it was found that a leak existed in the tank, and the record involving nearly thirty trips to the lake is rejected. The record from August 21 to November, after the tank was repaired, is given, as also a few weeks in May.

EXPLANATION OF THE TABLES.

§ 26. The column giving the net loss gives the depression of the water surface observed in the period given in the second column. The rain during the same period as measured at the Agricultural College at Fort Collins, is given in the next column. The total loss is the sum of the loss observed in the lake, increased by the amount of rainfall which has fallen in the meantime, or is the sum of the two preceding columns.

TABLE VII.—EVAPORATION OBSERVATIONS, LEE'S LAKE.—1896.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit.			Wind—Miles.		Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
		In Tank.	At Surface of Lake.	At Bottom of Lake.	Av. Movement per 24 hrs.	Maximum hourly Velocity.					
June 15....	..	76.0	76.0	....	....	....	....	...	....	....	Put tank in lake.
9 : 20 a. m. June 17....	2	75.5	73.7	....	113*	48	.50	T	.50	.250	
4 : 10 p. m. June 20....	3	75.8	75.8	....	160	30	1.60	T	1.60	.533	
1 : 15 p. m. June 24....	4	73.5	73.5	70.0	166	30	.20	.70	.90	.225	Rain gage at lake, 0.65 inches.
9 : 05 a. m. June 30....	6	72.5	72.5	69.0	126	40	-.20	.36	.18	.030	Rain gage at lake, 0.62 inches.
3 : 45 p. m. July 3....	3	75.3	75.3	71 0	151	16	.90	T	.90	.300	Rain gage at lake, 0.02 inches.
9 : 30 a. m. July 7....	4	76.0	....	72.0	122	12	1.00	.03	1.03	.258	Rain gage at lake, 0.02 inches.
9 : 30 a. m. July 8....	1	76 0	75.8	72.0	105	7	.20	T	.20	.200	Rain gage at lake, 0.02 inches.
4 : 00 p. m. July 11....	3	83.0	83.5	76.0	113	13	1.30	0	1.30	.433	
9 : 20 a. m. July 14....	3	75.0	74.8	73.0	146	17	.90	0	.90	.300	
10 : 40 a. m. July 18....	4	74.0	73.7	71.0	156	17	1.05	.28	1.33	.332	Rain gage at lake, 0.10 inches.
9 : 00 a. m. July 21....	3	73.0	73.0	70.5	152	11	.70	.37	1 07	.357	Rain gage at lake, 0.13 inches.
9 : 50 a. m. July 28....	7	74.0	71.0	68.8	126	21	-.60	2.30	1.70	.243	Rain gage at lake, 3.84 inches.
3 : 25 p. m. August 1..	4	79.0	79.0	70.0 ?	126	20	.90	.07	.97	.242	
9 : 30 a. m. August 4..	3	72.0	70.8	69.0	136	15	.80	0	.80	.267	
5 : 00 p. m. August 6..	2	75.5	76 8	68 6	147	24	.85	T	.85	.425	Rain gage at lake, T.
3 : 15 p. m. August 8..	2	74.0	74.2	71.2	176	15	.25	0	.25	.125	
9 : 00 a. m. August 11..	3	65.8	66.2	64.2	202	22	1.45	0	1.45	.483	
4 : 45 p. m. August 15..	4	71.5	72.0	67.2	150	17	.85	.02	.87	.217	Rain gage at lake, 0.02 inches.
9 : 00 a. m. August 18..	3	....	....	....	139	17	.40	0	.40	.133	Rain gage at lake, 0.20 inches.
3 : 45 p. m. August 22..	4	67.2	67.5	65.9	136*	17*	-1.35	2.02	.67	.168	Rain gage at lake, 1.90 inches.
9 : 40 a. m. August 25..	3	65.8	66.0	64.2	124	18*	.60	.02	.62	.207	
3 : 00 p. m. August 29..	4	74.6	74.8	65.8	119	17	.60	0	.60	.150	
9 : 30 a. m. Sept. 1....	3	70.2	70.8	66.2	111	16	.60	.14	.74	.247	Rain gage at lake, 0.06 inches.
3 : 35 p. m. Sept. 5....	4	74.0	74.2	65.6	157	15	.90	.04	.94	.235	From this on the rain gage at lake was so
9 : 35 p. m. Sept. 8....	3	65.0	65.2	63 9	148	20	1.30	0	1.30	.433	near the water that waves washed water in.
3 : 30 p. m. Sept. 12....	4	69.8	69.0	59.6	124	14*	-.10	.48	.38	.095	It seemed to rain more west of town.
10 : 00 a. m. Sept. 15....	3	67.6	66.8	61 8	112	....	.40	0	.40	.133	
9 : 15 a. m. Sept 22....	7	60.2	60.2	58.0	140	19*	.20	.55	.75	.107	
3 : 00 p. m. Sept. 26....	4	58.0	58.0	55.0	195	24	.30	.47	.77	.192	
9 : 50 a. m. Sept. 29....	3	58.0	57.8	56 0	118	10	.30	.01	.31	.103	
3 : 30 p. m. Oct. 3....	4	56.0	55 8	59.8	113	9	.70	0	.70	.175	
9 : 00 a. m. Oct. 5....	2	57.7	57.5	56.0	144	13	.20	0	.20	.100	
12 : 00 m. Oct. 13. ...	8	54.8	54.8	52.0	149	19*	1.30	.02	1.32	.165	Wind blowing.
3 : 30 p. m. Oct. 17....	4	57.5	56.3	54.2	140	15*	1.20	0	1.20	.300	
10 : 45 a. m. Oct. 20....	3	55.2	54.0	52.2	133	12	.20	0	.20	.067	
3 : 05 p. m. (ct. 24....	4	52.0	52.0	51.8	133	12	.30	.28	.58	.145	
10 : 15 a. m. Oct. 27....	3	49.0	48.8	48.2	124	15	.30	0	.30	.100	
3 : 00 p. m. Oct. 31....	4	44.8	44.2	42.2	256	26	-.10	.19	.09	.023	

* Days when electrical recorder was out of order. Some estimates included.

TABLE VIII.—EVAPORATION OBSERVATIONS, LEE'S LAKE.—1897.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
11 : 30 a. m. May 8	..	57.0	57.0	....	....	....	....	....	....	....	Put tank in lake.
9 : 20 a. m. May 11	3	60.8	59.7	59.2	188	30*	0	.10	.10	.033	
9 : 15 a. m. May 18	7	67.8	66 8	65.7	148	20*	1.50	.04	1.54	.220	Shower before measuring.
3 : 45 p. m. May 22	4	71.4	71.2	69 8	143*	22*	−1.10	1.50	.40	.100	
9 : 30 a. m. May 25	3	74.0	68.6	66.8	161*	19*	.60	.04	.64	.213	A few waves.
3 : 20 p. m. May 28	3	68 8	67.4	64.6	136*	18*	.20	.21	.41	.137	
9 : 00 a. m. June 1	4	....	....	....	142*	17*	.10	.35	.25	.062	No thermometer.
3 : 40 p. m. June 4	3	64.0	63.8	64.0	144	14	3.00	.63	(3.63)	....	A few waves.
9 : 45 a. m. June 8	4	72.8	65.2	64.5	121	11	.30	.39	.69	.172	
10 : 00 a. m. June 11	3	64.5	64.5	64.6	184	29	1.90	.10	2.00	.067	
9 : 25 a. m. June 15	4	72.0	71.2	70.6	114*	11*	4.70	0	(4.70)	....	
9 : 15 a. m. June 18	3	66.5	66.3	65.8	233*	27*	1.00	0	1.00	.330	Pulled ashore and nailed on boards so would float higher.
9 : 00 a. m. June 22	4	72.5	72.5	72.0	119	20	.70	.11	.81	.202	
10 : 00 a. m. June 25	3	68.5	69.0	69.4	149	14	.90	.28	1.18	.393	A few waves.
9 : 35 a. m. June 29	4	73.5	71.5	71.7	185	14	1.00	T	1.00	.250	
9 : 40 a. m. July 2	3	75.0	73.5	73.0	129	16	−.10	.05	−.05	....	
9 : 40 a. m. July 6	4	70.5	69.5	69.8	193	25	1.30	0	1.30	.325	A few waves.
2 : 10 p. m. July 9	3	71.8	71.3	71.0	136*	19*	−.40	1.18	.78	.260	
9 : 50 a. m. July 13	4	80.0	75.5	76.0	109*	10*	2.00	.32	(2 32)	....	
4 : 25 p. m. July 16	3	75.0	74.8	73.5	138	12	.90	0	.90	.300	Put rain gage on float.
10 : 25 a. m. July 20	4	68.5	67.0	66.3	141*	16*	.10	.89	.99	.247	Rain record at lake, .74 inches.
9 : 35 a. m. July 23	3	72.5	71.3	71.3	122*	9*	.70	0	.70	.233	Rain record at lake, 0.
9 : 45 a. m. July 27	4	73.1	71.2	71.6	133	18	.90	.21	1.11	.278	Rain record at lake, .19 inches.
9 : 30 a. m. July 30	3	75.0	73.0	72.1	121	22	−.90	0	−.90	....	
10 : 05 a. m. Aug. 3	4	73.1	71.6	72.0	142	24*	.80	.06	.86	.215	Rain record at lake, .33 inches.
9 : 25 a. m. Aug. 6	3	73.8	71.6	70.3	97	9*	.20	.37	.57	.190	Rain record at lake, .43 inches.
9 : 50 a. m. Aug. 10	4	75.0	72.5	71.1	107	8*	.40	.53	.93	.233	Rain record at lake, .34 inches.
11 : 30 a. m. Aug. 13	3	74.8	73.7	72.5	100	14	.85	.03	.88	.293	Rain record at lake, T.
10 : 00 a. m. Aug. 17	4	74.0	72.9	71.0	103	13	1.00	T	1.00	.250	
9 : 30 a. m. Aug. 20	3	69.8	69.2	68.2	116	10	.85	.67	1.52	.507	Rain record at lake, .13 inches.
9 : 30 a. m. Aug. 24	4	69.9	68.8	68.0	120	11	1.20	0	1.20	.300	Rain record at lake, 0.
9 : 40 a. m. Aug. 27	3	69.9	68.7	67.7	131	11	.85	T	.85	.283	Rain record at lake, 0.
9 : 30 a. m. Aug. 31	4	71.5	69.0	67.2	138	22	.95	.13	1.08	.270	Rain record at lake, .08 inches.
10 : 30 a. m. Sept. 6	6	71.0	70.8	67.0	99*	12*	1.10	0	1.10	.183	Rain record at lake, 0.
9 : 30 a. m. Sept. 11	5	65.0	66.0	....	129*	16*	1.70	.01	1.71	.342	
4 : 30 p. m. Sept. 22	11	71.0	72.4	60.0	115*	19*	....	.74	....	....	Rain gage full of water.
9 : 45 a. m. Oct. 1	9	63.6	63.9	62.0	97	12*	4.85	T	5.59	.280	
10 : 00 a. m. Oct. 19	18	49.0	47.5	45.8	131*	28*	2.50	.49	2.99	.166	
1 : 35 p. m. Oct. 27	8	46.7	46.5	....	182*	27*	.20	.26	.46	.058	
9 : 30 a. m. Nov. 2	5	47.0	45.0	43.2	193	19*	1.30	0	1.30	.260	
9 : 45 a. m. Nov. 11	....	....	....	....	....	....	....	....	....	....	Hole shot into pontoon.

* Electrical register out of order for portion of period.

TABLE IX.—EVAPORATION OBSERVATIONS. LOOMIS LAKE.—1897.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit.			Wind—Miles.		Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
		In Tank.	At Surface of Lake.	At Bottom of Lake.	Av. Movement per 24 hrs.	Maximum hourly Velocity.					
11:00 a. m. May 12	..	61.0	61 0	58.2	....	....	....	....	....	....	Put tank in lake.
9:45 a. m. May 19	7	67.8	65.0	62.8	146	22*	1.65	.04	1.69	.241	
2:25 p. m. May 22	3	67.5	69.0	66.0	141*	22*	-.60	1.50	.90	.300	
3:00 p. m. May 25	3	68.8	68.7	68.0	159*	19*	.80	.04	.84	.280	
2:30 p. m. May 28	3	57.2	57.0	62.5	148*	18*	.50	.21	.71	.237	
2.30 p. m. June 1	4	....	....	....	132*	17*	.60	.35	.95	.238	
2:15 p. m. June 4	3	63.3	63.2	63.0	138	14	.20	.63	.83	.277	
3:30 p. m. June 8	4	69.8	69.0	63.7	121	11	.30	.39	.69	.172	
9:50 a. m. June 11	3	63.0	63.0	62.2	172	29	2.30	.10	(2 40)	(.800)	
4:00 p. m June 15	4	71.0	71.0	65.5	119*	11*	1.10	0	1.10	.275	
2:45 p. m. June 18	3	67.3	67 0	66.2	238*	27*	2.20	0	(2.20)	(.733)	
3:00 p m. June 22	4	76.5	75.0	69.0	114	20	1.10	.11	1.21	.302	
9:05 a. m. June 25	3	67.3	67.5	68.6	150	11	.60	.28	.88	.393	
4:10 p. m. June 29	4	75.0	75.5	71.5	138	14	1.40	T	1.40	.367	
12:00 m. July 2	3	72.0	71.5	71.0	133	19	.70	.05	.75	.250	
3:25 p. m. July 6	4	....	....	....	192	25	....	0	....	...	
11:00 a. m. July 9	3	....	....	...	167*	19*	....	1.18	....	....	
10:00 a. m. July 14	5	....	72.0	71.0	116*	12*	....	.32	....	....	
8:45 a. m. July 16	2	72.5	71.3	69.0	126	12	.90	0	.90	.450	
3:20 p. m. July 16	½	75.5	74.5	69.3	165	10	.20	0	.20	.400	
9:00 a. m. July 20	3½	66.8	65.2	66.0	142*	16*	.30	.89	1.19	.297	
8:45 a. m. July 23	3	69.5	69.0	67.0	123*	7*	.70	0	.70	.233	Rain record at lake, .69 inches.
8:50 a. m. July 27	4	69.5	69.3	69.1	133	18	1.40	.21	1.61	.402	
8:40 a. m. July 30	3	70.5	70.2	70.3	122	22	1.80	0	1.80	.600	Rain record at lake, .15 inches.
9:10 a. m. Aug. 3	4	71.5	71.0	69.8	143	24	1.20	.06	1.26	.315	
8:40 a. m. Aug. 6	3	72 3	71.2	69.8	97	9*	.10	.37	.47	.157	Rain record at lake, .08 inches.
9:00 a. m. Aug. 10	4	72.5	71.7	70.1	108	11*	.50	.53	1.03	.258	Rain record at lake, .22 inches.
12:45 p. m. Aug. 13	3	73.3	73.6	72.8	108	14	1 00	.03	1.03	.343	Rain record at lake, .49 inches.
9:15 a. m. Aug. 17	4	71.8	70.7	70.3	119	13	1.15	T	1.15	.288	Rain record at lake, .02 inches.
8:45 a. m. Aug. 20	3	70.0	68.8	67.2	117	11	.60	.67	1.27	.423	Rain record at lake, T.
8:40 a. m. Aug. 24	4	69.3	69.2	68.2	119	11	1.20	0	1.20	.300	Rain record at lake, .22 inches.
8:45 a. m. Aug. 27	3	68.0	68.1	67.9	131	11	.90	T	.90	.300	Rain record at lake, 0.
8:45 a. m. Aug. 31	4	68.8	68.2	67.2	138	22	1 00	.13	1.13	.282	Rain record at lake, .04 inches.
5:30 p. m. Sept. 22	22	68.0	68 2	68.9	120	19*	....	.73	....	....	Rain record at lake, .09 inches.
6:00 p. m. Sept. 26	4	66.4	66.2	62.7	110*	9*	-.75	0	-.75	-.187	Rain gage, considerable water in.
8:50 a. m. Oct. 1	5	63.5	64.0	63.2	101*	12*	2.20	T	2.20	.440	Rain record at lake, .01 inches.
9:10 a. m. Oct. 19	18	47.0	47.3	46.8	136*	28*	2.80	.49	3.29	.183	Rain record at lake, T.
1:55 p. m. Oct. 27	8	46.5	45.5	....	181*	27*	-.20	.26	.06	.008	Rain record at lake, .46 inches.
1:30 p. m. Nov. 2	6	50.0	45.5	45.5	161	19*	1.70	0	1.70	.283	Rain record at lake, .32 inches.
4:00 p. m. Nov. 11	9	42.5	42.5	41.6	244	75	....	.04	....	....	
3:35 p. m. Nov. 18	7	42.0	41.0	40.0	130	19	.05	.34	.39	.056	Storm drove ashore and upset; put out again.

* Electrical recorder out of order for portion of period.

TABLE X.—EVAPORATION OBSERVATIONS, CLAYMORE LAKE.—1897.

Date.	No. of Days Interval.	Temperature of Water. Degrees, Fahrenheit. In Tank.	At Surface of Lake.	At Bottom of Lake.	Wind—Miles. Av. Movement per 24 hrs.	Maximum hourly Velocity.	Fall of Water Surface since Previous Obs.	Rainfall at College since Previous Obs.	Total Loss since Previous Obs.	Average Loss per Day.	Remarks.
12 : 00 m. May 1.....	.	59.2	59.2	....	....	....	....	....	....	....	Tank put in lake.
9 : 55 a. m. May 4.....	3	63.0	58.0	....	206	26	.63	0	.63	.210	
1 : 10 p. m. May 11.....	7	62.0	60.4	58.2	181	30*	1.52	.10	1.62	.231	
1 : 25 p. m. May 18.....	7	67.5	65.5	63.3	150	20*	-.10	.04	(-.06)	-.009	
3 : 45 p. m. May 22.....	4	71.4	71.2	69.8	131*	22*	-1.30	1.50	.20	.050	Waves on lake. Shower before measuring.
10 : 00 a. m. Aug. 21....	..	68.2	68.2	....	....	....	....	0	....	....	
12 : 30 p. m. Aug. 24....	3	74.8	70.3	69.3	123	11	1.15	0	1.15	.383	Rain record at lake, .14 inches.
10 : 20 a. m. Aug. 27....	3	72.0	69.0	67.6	131	11	.60	T.	.60	.200	Rain record at lake, .01 inches.
1 : 00 p. m. Aug. 31....	4	74.0	70.0	68.8	137	22	1.00	.13	1.13	.282	Rain record at lake, .16 inches.
11 : 30 a. m. Sept. 6....	6	73.0	70.0	67.3	121*	12*	1.00	0	1.00	.167	
5 : 45 p. m. Sept. 11....	5	71.0	71.0	67.0	129*	16*	1.25	.01	1.26	.252	Rain record at lake, .04 inches.
2 : 40 p. m. Sept. 21....	10	65.0	67.0	62.0	119*	19*	-1.05	.74	(-.31)	....	Rain gage filled by water from lake
10 : 40 a. m. Oct. 1.....	10	64.2	64.6	61.9	105	8*	.90	T.	.90	.090	Rain record at lake, .06 inches.
1 : 20 p. m. Oct. 19.....	18	54.0	51.0	50.8	143*	28*	.03	.48	.52	.029	Rain gage full of water.
1 : 00 p. m. Oct 27.....	8	45.0	45.0	....	182*	27*	-1.10	.26	(-.84)	....	Rain gage full of water.
12 : 15 p. m. Nov. 2.....	5	54.0	47.0	45.2	190	19*	....	0	.70	.140	
2 : 30 p. m. Nov 11.....	..	....	....	....	....	....	....	....	....	....	Tank damaged and brought in.

* Days when electrical register was out of order. Some estimates included.

§ 27. A tank similar to those used as a basis of measurement in the lakes already mentioned, was placed in Warren's lake, four miles southeast of the College, floated by pontoons and observed weekly during 1889 and 1890. The lake was a resort for fishing, and the tank was often interfered with, so that the observations were abandoned after the two years experience.

TABLE XI.

1889.	No. Days.	Temperature. Degrees, Fahrenheit.	Loss—Inches.	Rain at College—Inches.	Total Loss—Evaporation—Inches.	Loss per Day—Inches.
June 25 to July 11	16	72—74	2.65	.40	3.05	.19
July 11 to July 19	8	74—74	1.31	.39	1.70	.21
July 19 to July 27	8	74—73	2.50	.50	2.50	.31
July 27 to August 1	5	74—72	1.56	0	1.56	.31
September 4 to September 9	5	66—68	1.34	0	1.34	.27
September 9 to September 20	11	68—62	2.39	.28	2.67	.24
September 20 to September 28	8	62—60	1.86	.10	1.96	.25
September 28 to October 4	26	60—59	1.28	0	1.28	.21
October 4 to October 17	13	59—54	1.46	.44	2.00	.15
October 17 to October 25	8	54—52	1.92	.02	1.94	.24

TABLE XII.

1890.	No. of Days.	Temperature. Degrees, Fahrenheit.	Loss—Inches.	Rain at College—Inches.	Total Loss—Evaporation—Inches.	Loss per Day—Inches.
April 30 to May 6	6	57	.86	.40	1.26	.21
May 25 to June 1	7	62—66	1.98	0	1.98	.28
June 14 to June 21	7	74	1.90	0	1.96	.28
June 28 to July 5	7	76—74	.83	.42	1.25	.18
July 5 to July 12	7	74—78	1.52	.05	1.57	.22
July 19 to July 26	7	76—79	1.82	.42	2.24	.32
July 26 to August 2	7	79—77	.05	.35	2.40	.34
August 2 to August 9	7	77—72	2.15	.06	2.21	.32
August 9 to August 23	14	72—74	1.13	3.08	4.20	.30
August 23 to September 1	10	74—70	1.40	T	1 40	.14
September 22 to September 26	4	63—62	1.96	0	1.96	.49
September 26 to October 3	7	62	1.73	T	1.73	.25

The observations were taken in the afternoon between 2 and 5 p. m., generally about 3 p. m., or near the highest temperature of the day.

A similar tank was placed in the Arthur ditch where it passes through the College grounds. Observations were taken daily. While not the same as reservoir conditions, it gives data for comparison:

June, 1889	2.89 inches	Record based on	16	days
July, 1889	4.13 "	" "	31	"
August, 1889	3.94 "	" "	21	

§ 28. From the above data we obtain the basis for estimating the evaporation at the same rate for the calendar months:

TABLE XIII.

Lee Lake—1896.			Lee Lake—1897.		
Month.	Evaporation —Inches.	No. Days Record.	Month.	Evaporation —Inches.	No. Days Record.
....	....	..	May	4.31	24
June..........	6.36	15	June.....	9.55	21
July	9.11	32	July	8.53	21
August	7.25	31	August	8.61	32
September.....	5.20	32	September.....	8.40	31
October	4.17	28	October	4.60	32

Loomis Lake—1897.			Claymore Lake—1897.		
May	7.89	20	May	5.22	14
June.	7.91	26	June..........	....	..
July........	11.87	20	July..........	....	..
August	9.02	32	August	8.93	10
September.....	....	..	September.....	4.81	21
October	4.89	32	October	1.62	23

Warren's Lake—1889.			Warren's Lake—1890.		
May	....	..	May..........	7.71	13
June..........	....	..	June	8.40	7
July	7.37	37	July	5.41	29
August	....	..	August	8.06	38
September.....	7.25	30	September.....	....	..
October	5.61	21	October	....	..

§ 29. It will be noticed that the evaporation from the tanks as given is much greater than the corresponding tank on the grounds of the Agricultural College. This difference is partially but not entirely due to temperature. The tanks in the lakes are more freely exposed to the wind than the standard tank, and this would therefore make a great difference. The tanks are more or less agitated by waves, and in consequence the water surface exposed to the air is larger than the cross section of the tank. A film of water is also left on the metal sides of the tank with every movement, and this is apt to be of higher temperature than the water in the lake or in the tank, and evaporates more rapidly. The influence has been noticed by Mr. Trimble, who made the observations in 1896 and some of those in 1897, and suggested as a cause of some of the excess of evaporation observed from the lakes. The effect may be considerable, but how much is uncertain. The wave action differs in the different lakes. In Lee lake the weeds extend so near the surface that there is little opportunity for wave formation. In the other two lakes the effect is greater. As the wave also increase the area of the surface of the lakes which is exposed to the air likewise, the result is possibly closer to the loss from a lake exposed to the wind than if the tank had been stationary.

§ 30. The effect of such increase of surface may be considerable. We have made no experiments to determine the possible effect. The only ones reported are some by Maurice Aymard, a French engineer stationed in Algeria, whose report on Irrigation in Spain as prelimi-

nary to the construction of a reservoir which has but recently been built, is classic in irrigation literature. The observations were carried on for less than four days in 1849. Tanks 20 inches (50cm) in diameter and 2 feet high were made. In one the water was still; in the other an iron disk nearly of the same diameter as the tank, with holes through it, was slowly raised and lowered in the tank. The water passing through the numerous small holes, kept the surface in agitation, something like the surface in small ditches with rapid fall. The loss under these conditions was more than a third more from agitated than from the quiet water, or a loss of 1.66 inches from the quiet water. and of 2.32 from the rough water.*

ESTIMATE OF EVAPORATION FROM RESERVOIR.

§ 31. From the preceding data we may estimate the amount of evaporation under reservoir conditions. Any such estimate is subject to the uncertainties already mentioned, and to the condition that the evaporation may vary much from year to year, and from one body of water to one immediately adjacent. Nevertheless we may make what may be considered a reasonable estimate from the observations.

	Evaporation.		Evaporation.
January	1.5 inches.	July	9.5 inches.
February	2.0 "	August	8.5 "
March	3.5 "	September	6.5 "
April	5.0 "	October	4.5 "
May	6.5 "	November	2.5 "
June	8.0 "	December	1.5 "
Total			59.5 inches.

§ 32. The following are other cases of evaporation which have been observed. On several lakes in California, observations were made in 1879 by J. D. Schuyler, now consulting engineer, of Los Angeles, Cal. They are reported in William Ham Hall's report as State Engineer of California in 1880, and in Physical Data and Statistics of California:

Reeder lake is a narrow lake with wooded shores, water 12 to 15 feet deep. Evaporation pans two by two feet square and one foot deep were used. They were protected from the wind but exposed to the sun. From June 25th to July 11th, a total of sixteen days, the loss was 1.21 inches, or an average of .24 inch per day. The temperature of the water from five observations taken late in the afternoon, varied from 82° to 92°, which would be higher than the average temperature.

In Panama Slough, California, July 9th to August 20th, 1879, a loss of 2.46 inches in a little over seventeen days, was noticed, or an average of .145 inch per day. The temperature of the water was from 64° to 72°.

* Debauve, Manuel de l'Ingenieur, Des Eaux en Agriculture, p. 170. Parrochetti, Manuale pratico di Idrometria, pp. 256-8.

In Kern lake, Mr. Schuyler also made observations from Aug. 4th to Sept. 29th. In a tank near the shore, the daily evaporation was .30 of an inch. In a tank near the shore in a depth of 5 feet of water, the daily loss during the same time was .21 of an inch per day. The temperature of the water as given was the same in each case, and varied from 78° to 88°. About noon the air was considerably warmer. From Oct. 2nd to Dec. 20th, a period of seventy-nine days, evaporation amounted to 9.66 inches from Kern river, Cal. This was determined from weekly observations. The temperature of the water in the pan varied from 55° to 80°. The average daily loss was .12.

At Sweetwater reservoir, near San Diego, California, an evaporation tank was put in place by J. D. Schuyler and has since been continued by and under the direction of H. N. Savage, C. E. The reservoir was visited by the writer in 1891. At that time a circular tank, floated in the lake, was used. A Piche evaporometer was used for comparison. When the pan gave out in 1892, it was not renewed, and the records were made from the Piche instrument until 1897, when Mr. Savage had the pan replaced. As the records with the Piche evaporometer do not show the evaporation from free water surface, they are not used in the table which follows, and only those depending on the records from the tank are given. Mr. Savage has furnished the record up to date.

TABLE XIV.—EVAPORATION FROM SWEETWATER RESERVOIR.

Near San Diego, California. Latitude, 32° 40'; longitude, 117°; elevation, 220 feet.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1889........	1.99	3.34	3.38	4.96	5.82	6.81	8.22	7.26	7.81	4.52	3.96	.95	59.02
1890........	1.59	2.21	3.28	4.14	6.14	7.30	7.38	9.02	6.48	4.92	5.54	1.84	59.84
1891........	3.61	1.35	3.08	3.71	5.60	6.03	6.50	8.89	6.15	6.31	4.10	2.75	58.08
1892........	2.54	1.39	3.08	5.82	4.67	6.48	8.81	6.54	6.27	6.56	4.77	2.61	59.54
1897........	2 12	1.64	2.91	5.99	5.69	7.90	6.25	6.61	5.53	6.27	4.24	3.75	58.90
Mean......	2.37	1.99	3.15	4.92	5 58	6.90	7.43	7.66	6.45	5.72	4.52	2.38	59.07

The water temperature ranged from an average of 80 to 82 degrees, in the warmest month, to 50 degrees, in the coolest.

§ 33. A valuable series of observations is being carried on by H. B. Hedges, C. E., of San Bernadino, Cal., at the Arrowhead reservoir in Little Bear valley. This is at an elevation of 5,160 feet above sea level, and near enough to San Diego to furnish some comparison between the evaporation at those two places and indicating the effect of elevation.

In this case the evaporation was measured in a three-foot pan floated in a concrete basin separate from the reservoir. Measurements are made twice daily at 6 a. m. and 6 p. m. in summer. It will be noticed that the evaporation is much less than at San Diego.

TABLE XV.—EVAPORATION FROM THE ARROWHEAD RESERVOIR.

Little Bear Valley, California. Latitude, 34° 16'; longitude, 117° 11'; elevation, 5,160 feet. By H. B. Hedges, C. E.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1895........	....	....	1.12	1.84	5.30	6.60	6.30	6.20	5.05	2.80	1.20	.34	......
1896........	.09	.81	.94	3.39	2.86	6.50	5.04	5.50	4.01	4.05	1.28	1.23	35.70
1897........	.57	.24	....	3.01	4.75	6.17	7.62	5.17	5.00	4.01	1.24	1.21	......
Average...	.33	.53	1.03	4.12	4.30	6.42	6.32	5.62	4.69	3.62	1.24	.93	39.15

§ 34. The following are records of the average evaporation from floating tanks made at Rochester, New York, and at Boston Mass. The former were made under the direction of Emil Kuichling, chief engineer of the water works, and were made in small indurated fiber tubs, about 10 inches in diameter and six inches deep. At Boston the observations were made under the direction of Desmond Fitz-Gerald on the Chestnut Hill reservoir. Those at Rochester are dependent on records from one to five years of the different months, at Boston upon a much longer period. Those at Boston are not the actual means of observation, but the smoothed values determined by the application of Bessell's formula to reduce periodic series:

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rochester.	.45	.45	.91	2 67	4.05	4.93	5.65	5.28	4.07	3.13	1.50	1.22	34.31
Boston.....	1.12	1 20	1.81	3.01	4.48	5.55	5.98	5.50	4 20	3.14	2.22	1.50	39.71

THE EFFECT OF ELEVATION ON LOSSES.

§ 35. Are the losses more or less at high elevations? Is it more economical to store water at low or high elevations?

For increase of elevation the evaporation, if the wind conditions are the same, is greatly diminished. Practically the opportunities for storage are confined to basins not over 10,000 feet in elevation, and the question of the evaporation is of most importance for elevations below that height. Observational data are almost entirely lacking. Such observations as have been made are not under the same methods and not strictly comparable.

As far back as 1890, I made attempts to obtain such data and furnished evaporation tanks to several places, distributing some tanks coming from the U. S. Irrigation Survey of 1889–90 and also some new tanks. The highest point was at the U. S. Fish Hatchery near Leadville, at an elevation of nearly 10,000 feet. Few results were obtained except from the sub-stations connected with the College in the San Luis valley and on the Divide, at elevations of 7,600 and 7,200 feet respectively. The other observers were voluntary, and as there were no funds to replace the broken instruments or repair the damaged tanks, the observations were abandoned. In the absence of observations, we may consider the probable effects.

§ 36. We may dismiss the losses from seepage from consideration. They depend upon the character of the site and nothing in the mere elevation would increase or diminish the seepage, unless the lower temperature of the soil should lessen the rapidity of seepage, and this, as shown in Bulletin 33, may be considerable. In general the rock strata are nearer the surface in the mountains and more attention may well be given to the geological characteristics of the site.

§ 37. But elevation has an influence on evaporation, and as evaporation is shown to be of more importance in the cases examined, the effect of elevation on losses will be principally due to its effect on evaporation.

§ 38. The factors controlling evaporation, are:

First—The temperature of the surface of the water, which indicates the limit of the amount of vapor which the air in contact with the water will absorb.

Second—The amount of moisture present in the air. The difference between the moisture corresponding to the temperature of the water surface, and the moisture actually present, is a measure of the additional amount of vapor which the air will take up.

Third—The wind movement.

§ 39. The temperature of the air is decidedly lower at high elevations, though on individual days inversions may occur, and the air be warmer at the high elevations. This is often shown in comparing the observations taken at the College, with those taken by Mr. C. E. Lamb at the foot of Long's peak. This inversion occurs principally in the winter months, between November and April, and has less effect on evaporation than if occurring in the summer.

Taking the records from several places, we find the average temperatures as follows, where the lower temperature with increased altitude is to be noted:

	Latitude.	*Elevation.*	*Av. Temp.*
Agricultural College, Ft. Collins	40° 34′	5,000 ft.	47°.7
Denver	39° 45′	5,300 ft.	49°.5
Colorado Springs	38° 50′	6,100 ft.	47°.2
Lamb's, near Long's Peak	40° 20′	9,100 ft.	37°.0
Pike's Peak	38° 50′	14,147 ft.	19°.4

The difference of 8,000 feet in elevation between Colorado Springs and Pike's peak, causes a difference of 28° in mean annual temperature, equivalent to a difference of 1° for 300 feet rise.

§ 40. The temperature of bodies of water freely exposed to the air will not differ much from that of the air in contact with them. The temperature of the water surface averages higher than the whole body of water, because as the water warms, the heated layers remain on top for temperatures above 39°, while in cooling the water sinks as it cools and the whole mass cools together. Below 39° the colder

water remains on the surface. In heating, therefore, above 39° the whole mass is heated, and the increase in temperature is slow, while in cooling the surface cools without the mass of water cooling materially. Hence for temperatures above 39° the surface averages of higher temperature than the body of water, and for temperatures between 32° and 39° it averages lower. In the one case it tends to make the surface warmer than the air, in the other cooler.

In our evaporation tank it is noticeable that the temperature of the surface shows an excess of from 6° to 7° above the air temperatures.

At higher elevations similar differences prevail, and in all probability the differences are nearly the same, though exact observation is lacking. But as the prevailing temperatures are lower, the water temperature is less than the critical temperature of 39° for a greater part of the year than at lower elevations. It seems probable, therefore, that the excess of the water temperature above the air temperature is less than at the lower elevations.

§ 41. But even if more, the evaporation, so far as this factor is concerned, may be less, for as the evaporation seems to vary directly with the difference of vapor pressure corresponding to the temperatures of the water surface and of the air, and as the vapor pressures decrease much faster than the temperatures, the same difference in degrees means a greater difference in vapor pressure, or a greater capacity for moisture at a high temperature than at a low. Thus the table shows the pressure of the water vapor corresponding to the ordinary air temperatures.

Temperature.	*Corresponding Vapor Pressure.*
100 degrees.	1.91 inches.
90 "	1.40 "
80 "	1.02 "
70 "	.73 "
60 "	.52 "
50 "	.36 "
40 "	.25 "
30 "	.17 "
20 "	.11 "

From this table a difference of 10° would correspond to a difference of vapor pressure or capacity for moisture:

For 10 Degrees Difference.	*Difference of Vapor Pressure.*
Between 80 and 70 degrees.	.29 inches.
" 70 and 60 "	.22 "
" 60 and 50 "	.16 "
" 50 and 40 "	.11 "
" 40 and 30 "	.08 "

Since the evaporation varies directly as this difference of vapor pressure, or, so far as this factor is involved, when the temperature of

the water surface is 80°, the evaporation would be $3\frac{1}{2}$ times as fast as when the temperature is 40°, the excess above dew point being 10° in each case.

But at the low temperatures corresponding to high elevations, the dew points are nearer the air temperatures than at higher temperatures. In addition, there is reason to believe that the water temperature is not so much above the air temperatures as at higher temperatures. It is evident that the effect of these conditions is to make the difference of vapor pressures corresponding to the temperature of the water surface, and of the dew point to be less at high elevations than at low, and by so much to reduce the evaporation.

§ 42. On the other hand, the lessened air pressure at the higher elevations is favorable to increased evaporation, the increase in evaporation being proportional to the decreased pressure, and the influence of elevation being to increase the evaporation by the per cent given in the third column. This increase is due to the decreased barometric pressure alone.

Elevations.		*Pressures.*		*Increase in Evaporation Over Evap. at 5,000 Feet.*	
5,000	feet	25	inches	00	per cent.
6,000	"	24	"	$3\frac{1}{2}$	"
7,000	"	23.2	"	7	"
8,000	"	22.3	"	11	"
9,000	"	21.4	"	14	"
10,000	"	20.6	"	18	"
11,000	"	19.9	"	20	"
12,000	"	19.1	"	24	"
13,000	"	18.4	"	26	"
14,000	"	17.7	"	29	"

§ 43. Confining these effects to elevations less than 10,000 feet, which is practically the limit of available storage sites, we find that the condition of air and water temperatures materially reduce the evaporation, the decreased barometric pressure increases, and the wind, if greater, would tend to increase it. The effect of lower temperatures is greater than the increasing effect of the barometric pressure and probably greater than the effect of the wind, except in exposed places. And when we take into account the fact that the water is frozen for a much longer period of the year, it is safe to conclude that the evaporation for the year is much less than at lower elevations.

§ 44. The amount of decrease cannot be stated with certainty. An increase in wind increases the evaporation, each mile of wind during the twenty-four hours, increasing the evaporation for that day by from 1 to 2 per cent.; 2 per cent. deduced from Fitz-Gerald's formula from Boston observations,† and nearly 2 per cent. for wind of 5 miles per hour, decreasing to 1 per cent. for each mile at 25

miles per hour, as deduced from Professor Russel's observations; ‡ 2 per cent. from Colorado observations of 1889, by L. G. Carpenter.*

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§45. SUMMARY AND CONCLUSIONS.

1. The losses from reservoirs are from seepage and evaporation.

2. The seepage losses are dependent on the condition of the reservoir site, therefore different for different sites.

3. The seepage losses were determined on a series of reservoirs near Fort Collins, in the winter of 1895–6 and 1896–7.

4. The seepage losses may be great. In the lakes under measurement, the losses in some cases were less than from evaporation alone.

5. In some cases, lakes may gain from seepage from irrigated lands, and the gain may be more than the combined loss from seepage and evaporation.

6. In the cases where loss from seepage occurred, the loss was at the rate of about 2 feet in depth over the area of the lake, per year.

7. This amount does not necessarily apply to other sites, and other observations are needed before general statements respecting loss from this source can be made.

8. The seepage decreases after the lake is first filled, from the effect of silting, and from having filled the porous ground underneath and connected with the site.

9. Even in sand, there is a limit to the amount of seepage, and the time during which the loss is large.

10. After sand beds connected with the reservoir are saturated, the losses from seepage will decrease.

10 *a*. The loss increases with the depth, probably nearly as the square.

11. The losses may be lessened, though not entirely prevented, by silting.

12. The silting process is more efficient with small reservoirs, because of the better distribution of the silt.

13. If the loss from seepage is not more than 2 feet per annum, the sites may be considered as practically water tight. In the case of canals, the losses often average more than that in twenty-four hours.

EVAPORATION.

14. The losses from evaporation, in the cases examined, are greater than those from seepage.

15. The evaporation is not necessarily the same from adjacent bodies of water.

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† Trans. Am. Soc. C. E., 1883. ‡ U. S. Weather Bureau. * Report Exp. Sta., 1889.

16. The amount of evaporation increases with the temperature of the water, with the wind, and diminishes with increased moisture in the air.

17. From the standard evaporation tank at the Experiment Station, the average evaporation for 11 years, has been 41 inches.

18. Evaporation proceeds when the water is frozen, but at a diminished rate; averaging about 1 to 1½ inches per month.

19. The evaporation at night is the same as during the day, the difference being less with the increase of the size of the bodies of water.

20. The loss by evaporation from several lakes exceeded that from the standard tank.

21. The loss from the lakes was about 60 inces per year.

22. The increase is due to higher temperature of the water, and to freer exposure to the wind.

23. In some of the summer months, the lakes lost twice as much as the standard tank.

24. The lower temperature of water at high elevations, and the lower dew points, tend to decrease the evaporation.

25. The diminished barometric pressure tends to increase the evaporation, amounting to 14 per cent at 8,000 feet, and to 18 per cent at 10,000 feet, over the evaporation at 5,000 feet.

26. Every mile of wind movement in 24 hours increases the evaporation by from 1 to 2 per cent over the evaporation if calm.

27. The winter period is longer at the high elevations.

28. For the whole year, the evaporation in all probability is considerably less at the high elevations than at the low ones.

29. Evaporation is lessened by any influence which diminishes the wind or decreases the temperatnre of the water.

30. Protection of lakes by wind breaks is in many cases practicable, and in small lakes sometimes desirable. In the large lakes the benefit is by reducing the wind velocity; in small lakes both from effect on wind and by lessening action of sun.

31. The deeper the lake the cooler the water as a whole, the cooler the surface, consequently the less evaporation.

32. Assuming a loss of 5 feet in depth per annum, an area of 100 acres would require ¾ cubic feet per second for the whole year to make good the losses from evaporation; one of 500 acres would require 3½ cubic feet per second, considerably more than would be used to irrigate an equal area.

33. The net loss to the reservoir would be the sum of the above losses from seepage and from evaporation, diminished by the rainfall, a combined loss which may be considered as a depth of 6 feet in one year.

34. As irrigation reservoirs are usually full for a few months only, the loss is much less than this for the high water area.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 46.

A Soil Study:

PART I.

The Crop Grown: SUGAR BEETS.

Approved by the Station Council.

ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JUNE, 1898.

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A Soil Study:

Part I. The Crop Grown: SUGAR BEETS.

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Among the many questions arising in the practice of irrigation, is the one in regard to the prevention of the alkalizing of low and poorly drained land.

The accumulation of water may not be so rapid that the land becomes waterlogged, though this, in many instances, actually occurs; yet the supply of water, laden with salts, dissolved out of the soil through which it has passed, is sufficient to cause, by its evaporation, a deposition of large quantities of these salts on, and in, the upper portion of the soil. This concentration of the salts is not always indicated by an efflorescence, though this frequently occurs.

The condition upon which the poor drainage depends, is usually the configuration of the surface, but the character of the land and of the strata underlying the soil contribute materially in bringing about this condition.

The difficulty is met with, mostly in limited areas, it is true, but so frequently, and that in otherwise good land, that it becomes a question whether we cannot ameliorate it in some way. Perfect drainage would answer all questions, but this is frequently difficult to obtain, or altogether impracticable. It is, however, not to be inferred that alkalized land is necessarily swampy land, or has such a supply of water that irrigation is unnecessary. Neither of these conditions obtain in general, or when they do, particularly the former,

the land must simply be abandoned. The plot chosen for this study is representative of this class of land; it is neither so wet as to be untillable, nor so badly alkalized as to be hopeless.

I recognize that this, like every other agricultural problem, is an involved one, and that it is difficult to determine to which factor the greatest importance should be given. In the present case, there are several patent questions, such as: Does the alkali present produce any effect upon the plant? Is its action directly upon the plant itself or does it act indirectly upon the plant through its effects, mechanical or chemical, upon the soil? Is the starvation of the plants observed in this case, due to an actual deficiency of available plant food, or to the mechanical conditions which obtained? Which is to be taken as the alkali in any given case, the efflorescence, the leachings from the soil, or the salts in the ground water, etc.

I shall devote the subsequent portion of this study to the consideration of the soil and ground water. In this I shall consider the crop grown.

I have chosen to pursue this investigation in a comparative way, believing that this gives the most satisfactory method of checking both observations and results. For this purpose, I selected two plots planted to beets by the Agricultural Department. The beets were of different varieties, and the soils were both good and presumably free from alkali. The investigation was begun and carried on upon the assumption that the character and relative quantities of the soluble salts present have a direct and important bearing upon the amount and character of the mineral matters taken up.

The experiments made in California with sugar beets on alkali soil could not give results necessarily applicable to our case, because our alkali is quite different. The efflorescence, or alkali crusts, are the same, or essentially so, but the leachings of the soil are quite different; ours is much poorer in sodic carbonate and much richer in calcic sulphate. Our alkali crusts are correctly so called, but the salts held in solution in the ground waters, and the leachings of the soil, are both so rich in calcic sulphate that it seems a misnomer to speak of them as alkali, and it should be borne in mind that throughout this bulletin no distinction has been made between the incrustation forming on the soil and the soluble salts in the soil, though there is a great difference between them. The incrustations are sodic and magnesic sulphates, with small quantities of calcic sulphate and sodic chloride, together amounting to about six per cent., while the water residue is largely calcic sulphate, with sodic and magnesic sulphates in smaller quantities.

A brief description of the soil, and a statement of the general condition of alkalization, may be given in this place.

The soil varies from a loam, with some gravel, and having a clayey and somewhat calcareous subsoil, to a fine alluvium, which owes its origin partly to the washings from the immediately surrounding country, and partly to the action of former water courses. It can scarcely be said that there is a true hardpan underlying our experimental plot; but the whole soil, to a depth of five and a half feet, is very retentive of water, and there is a stratum of clay immediately above the gravel, which is quite as efficient in preventing a free passage of the water into the ground flow as a hardpan would be. The gravel below the clay is filled with water, and I believe that the ground water from the higher land to the west finds its way through this to the river.

The water in the alkalized basin and in the gravel stratum are quite independent of one another, so far as I have been able to discover by sinking holes or wells through the soil into the gravel and examining the water. Subsequent study may disprove this, but up to the present I have no reason to doubt it.

Portions of this plot are so rich in soluble salts that incrustations one-half inch in thickness form on the surface of the soil after irrigation, or other favorable conditions. Such are the general conditions of the soil in which I endeavored to grow a crop, in order to study, first, the effects of these conditions upon the crop, and, second, the effects of the cultivation and crop upon the soil.

It is my purpose to record, in this bulletin, the results obtained in regard to the first subject, reserving the further consideration of the second question for a future bulletin.

Several considerations led me to choose the sugar beet as the crop to be studied in this experiment: The whole crop is usable; the weight of the crop is fairly large; its culture has been made familiar to the public by numerous bulletins, and is commanding a large amount of public interest; but the most important one was that the beet is more tolerant of alkali than most of our culture crops. I shall follow the developement of the plant and its sugar content, but this is not the chief object had in view.

Directions for the cultivation of the crop form no part of my plan; besides, they have been given in great fullness by many others. The first question which suggests itself in this study, is: What is the effect of the alkalies on the germination of the seed?

GERMINATION EXPERIMENTS.

I had every reason to expect difficulty in getting a good, or indeed, any stand at all in parts of the plot. The character of the soil and the experience of others justified this expectation. As the general composition of our alkali had already been determined, a series

of experiments was instituted to determine, beforehand, whether a failure to get a stand should be attributed to the alkali, to the seed, or to some other cause. I also endeavored to determine the maximum amount of the constituent compounds of the alkali which might be present and still permit the seed to germinate. The amount of sodic chloride present in our alkali is so inconsiderable that it was excluded from our experiments, which were made with the other salts composing the alkali, *i. e.*, sodic carbonate, which is present in small quantities only, sodic sulphate, and magnesic sulphate. There is a very large amount of calcic sulphate in the soil, but no germination experiments were made with it.

My object, as already stated, was to determine the vitality of the seed, the effect of these salts upon the germination of the seed and upon the young plants. The salts were used separately, and also in conjunction, in quantities varying from 0.01 per cent. to 1.0 per cent. of the air-dried soil; for instance, 99 grams of clean, washed, and ignited sand, and 1 gram of dry, neutral sodic carbonate, were taken. The seed used were carefully selected, only fresh, plump burs being taken. The vessels used as germinating cups were ordinary glass tumblers. By using these we avoided the evaporation from the sides of the vessels, which would have taken place had a porous retainer, such as a flower pot, been used, and also any drainage and consequent washing out of the alkali. Evaporation from the surface, and too strong a light, were guarded against by covering each glass with a close-fitting disk of paste board. After the salts had been added to the sand, distilled water was used to wet the mass, and subsequently to replace that lost by evaporation.

The experiment extended over a period of 37 days, from April 11 to May 17, inclusive. The temperature was observed at 7:00 a. m., 12:00 m., and 6:00 p. m. The lowest temperature at 7:00 a. m. was on the day of planting, 46° F.; the highest temperature at this hour was 63° F.; the average of all the readings, 51°. The average temperature at noon for the entire period was 61° F., and at 6:00 p. m., 70° F.

The experiment was divided into four series: The first with sodic carbonate, the second with sodic sulphate, the third with a mixture of these two salts, sodic carbonate and sulphate, and the fourth with magnesic sulphate. The general results of the experiments only are given, because a detail of the daily record would show but little of interest, and occupy a great deal of space. The chief thing which would be gained would be the easily demonstrated fact that the seed germinate more quickly in the solutions of the soda salts, and more slowly in the magnesium salt, than when they are absent, and that the corrosive action of the sodic carbonate made itself manifest when so much as .05 per cent. of it was present in the soil.

SODIC CARBONATE, OR BLACK ALKALI, ALONE.

Variety of Seed Planted.	Per Cent. Sodic Carbonate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.00	20	18	90
Vilmorin	0 01	20	17	85
Vilmorin	0.02	20	17	85
Vilmorin	0.03	20	17	85
Vilmorin	0.04	20	18	90
Vilmorin	0.05	20	20	100
Vilmorin	0.06	20	18	90
Vilmorin	0.07	20	19	95
Vilmorin	0.08	20	19	95
Vilmorin	0.09	20	18	90
Vilmorin	0.10	20	15	75
Kleinwanzlebener	0.10	10	4	40
Imperial	0.10	10	9	90
White Imperial	0.20	10	2	20
Lion Brand	0.20	10	5	50
Kleinwanzlebener	0.40	10	0	00
Imperial	0.40	10	1	10
White Imperial	0.50	10	0	00
Lion Brand	0.50	10	0	00
Kleinwanzlebener	0.70	10	0	00
Imperial	0.70	10	0	00
Imperial	0.80	10	0	00
Lion Brand	0.80	10	0	00
Kleinwanzlebener	1.00	10	1	10
Imperial	1.00	10	0	00

SODIC SULPHATE, OR WHITE ALKALI, ALONE.

Variety of Seed Planted.	Per Cent. Sodic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Kleinwanzlebener	0.1	10	8	80
Imperial	0.1	10	10	100
White Imperial	0.2	10	10	100
Lion Brand	0.2	10	10	100
Vilmorin	0.4	10	5	50
Imperial	0.4	10	6	60
White Imperial	0.5	10	9	90
Lion Brand	0.5	10	8	80
Vilmorin	0.7	10	7	70
Imperial	0.7	10	7	70
White Imperial	0.8	10	5	50
Lion Brand	0.8	10	7	70
Vilmorin	1.0	10	1	10
Lion Brand	1.0	10	4	40

BLACK AND WHITE ALKALI—EQUAL PARTS.

Variety of Seed Planted.	Per Cent. Sodic Carbonate in the Soil.	Per Cent. Sodic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.05	0.05	10	1	10
Imperial	0.05	0.05	10	9	90
White Imperial	0.10	0.10	10	6	60
Lion Brand	0.10	0.10	10	7	70
Vilmorin	0.20	0.20	10	1	10
Imperial	0.20	0.20	10	2	20
White Imperial	0.25	0.25	10	2	20
Lion Brand	0.25	0.25	10	2	20
Vilmorin	0.35	0.35	10	0	00
Imperial	0.35	0.35	10	1	10
White Imperial	0.40	0.40	10	0	00
Lion Brand	0.40	0.40	10	1	10
Vilmorin	0.50	0.50	10	0	00
Imperial	0.50	0.50	10	0	00

MAGNESIC SULPHATE (EPSOM SALTS).

Variety of Seed Planted.	Per Cent. of Magnesic Sulphate in the Soil.	Number of Burs Taken.	Number Sprouted.	Per Cent. Sprouted.
Vilmorin	0.10	20	19	95
Vilmorin	0.20	20	17	85
Vilmorin	0.30	20	18	90
Vilmorin	0.40	20	20	100
Vilmorin	0.50	20	18	90
Vilmorin	0.60	20	17	85
Vilmorin	0.70	20	16	80
Vilmorin	0.80	20	18	90
Vilmorin	0.90	20	16	80
Vilmorin	1.00	20	19	90

The preceding experiments were conducted under identical conditions, and demonstrate that good beet seed will germinate freely in soil containing as much as 0.7 per cent. of white alkali, or sodic sulphate, but with as much as 0.1 per cent. of black alkali, or sodic carbonate, free germination of the seed is doubtful, and the action of the black alkali is scarcely, if at all, mitigated by the presence of an equal quantity of white alkali. The result obtained when 0.05 per

cent. of black alkali was present is less favorable than was obtained in the first series, when twice this amount, or 0.1 per cent., was present. This difference might have been partly due to the varieties used. It seems that the Vilmorin is more sensitive to the action of the alkali than the other varieties, but the experiments are not numerous enough to really establish this point, and it must also be remembered that another lot of Vilmorin seed might prove much hardier.

The next series of experiments was conducted with the sodic carbonate, or black alkali, alone, at a somewhat higher temperature, the average being 73.76° F., and the young plants were allowed to remain in the soil to enable us to see how long they would endure the alkali. The quantity of alkali added varied from 0.1 to 1.00, the quantity increasing regularly by 0.1 per cent. The variety of seed used was the Vilmorin; a blank was run at the same time. In six days, 90 per cent. of the seeds in No. 1, containing 0.1 per cent. black alkali, had germinated, none of the others containing alkali germinated, though the experiment was continued for twenty days. The seeds in the glass to which no alkali had been added all germinated, and continued to grow in a normal manner so long as we continued to observe them.

The glass containing 0.1 per cent. of sodic carbonate was allowed to remain five days after germinating, when the seedlings were noticed to be drooping. They were carefully removed from the sand by washing, and seven out of the nine had the plumule corroded, and the rootlets of the other two were already blackened. The blank was allowed to remain exposed to the same conditions for nine days longer, and at the end of this period were still healthy and growing. There can be no doubt but that the alkali had caused the death of the plants in the other glass, proving that, while 0.1 per cent. of black alkali in the soil will not prevent the germination of beet seed, the young plants cannot endure this amount. If the plant had already been established, before this percentage of the alkali had been brought into the soil, it might endure it. I am, however, inclined, by what I have seen of the deportment of the beet plant toward alkali, to doubt whether, even under such conditions, it would survive, especially if, as is the case in Colorado, there should be a rapid evaporation from the surface of the soil.

The next and last series of sprouting experiments* was made to study the effects of still smaller quantities of sodic carbonate, as the maximum amount of sodic carbonate which can be present without any serious disadvantage, evidently lies below one tenth of one per cent.

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* The results have been incorporated in the table under the heading of sodic carbonate.

This last statement ought to be modified to some extent, because there is no humus, or other substance, to ameliorate the action of the alkali, in which respect our tests do not resemble the true soil conditions. The humus in our Colorado soils is so small that it would, under all conditions, be a question whether its influence would be great enough to be observable. The result of this experiment was that the beet seed germinate more quickly in soils containing less than 0.10 per cent. of sodic carbonate, than in soils containing no alkali, but that the young plants cannot survive in the presence of 0.05 per cent. of black alkali, or sodic carbonate.

THE CULTIVATION AND COST.

General instructions for the proper cultivation of the sugar beet have been furnished to every section adapted to its culture, so that a repetition of them here would be useless, and I shall confine my statements on the subject of cultivation to a brief account of our operations, which I make that our conditions may be more fully appreciated.

The ground was plowed and subsoiled to a depth of 14 inches; it was then harrowed, planked and replowed, and still its condition was not a desirable one.

The seeds were drilled in, with the rows two feet apart, and the varieties three feet apart. The depth to which the seeds were put in was between two and three inches, but owing to the uneven condition of the ground this varied greatly. The plots were all planted on May 18, 1897. A rain storm set in on this day and the weather continued rainy until June 11. The beets began to come up on June 6, but, notwithstanding the favorable weather, they did not come up well. This was not to be explained by there being too much rain on a poorly drained soil, for on those portions which were under water for from three to five days there were many more plants than on some of the higher portions. The weather being rainy until June 11, the ground did not bake badly before the first hoeing, which was begun on June 14; but from this time on the soil baked badly and was very difficult to keep in any sort of tilth.

THE APPEARANCE OF INSECTS.

On June the 16th, I noticed a striped beetle, *Systena tæniata*, attacking the leaves. These beetles seemed to come from an adjacent fallow plot, which was covered with poverty weed. By June 21, they had become quite abundant and done considerable damage.

While the plants were quite young they were attacked by the leaf hoppers, *Agallia uhleri*, *Agallia sanguineolenta* and *Agallia cinerea*. Prof. Gillette, who determined these insects for me, is of the opinion that these hoppers did no appreciable harm, except while the plants were small.

Insecticides were applied on June 24, with very unsatisfactory results, and during the next few days it looked as though our insect enemies would defeat us.

We had already observed an occasional individual much larger than the striped beetle, *Monoxia puncticollis*. This beetle had become plentiful by July 3, and was doing considerable damage. On this date we sprayed with paris green, suspended in water, one pound to 80 gallons. This gave us the best satisfaction of all the insecticides which we tried.

THE EFFECT OF ALKALI.

The first observed effect of alkali was on June 15 and 16, when we observed some plants, in spots, at the east end of the plot, drooping, just as some had done in our sprouting experiments. Examination showed that the roots of the plants had been attacked, and were already black and dead. This was not due to the evaporation from the surface and concentration of the salts about the stem at the surface; such action was not observed until June 21, and was the worst in those spots where the efflorescences were the most marked. The effect of the alkali upon the roots was observed in spots where no incrustation appeared at any time. The presence of enough alkali to actually destroy the young plants was confined to certain spots, which were small, and gave no other evidence of either greater abundance or variation in character than that of its effect upon the plants. In fact, it appeared to be less abundant in these spots where it was fatal to the plants, than in other spots, near by, where the plants did well in the midst of a thick incrustation. Local variations in the composition, and, consequently, in the character of the alkali, within such narrow limits, may seem improbable to some, but I see no other explanation for these local effects.

I was not able to detect any corrosive effect of the alkali after the plants had become established, and the ground had been tilled and irrigated.

IRRIGATION.

The plot was irrigated twice, June 29–July 1 and August 18–20. The total rainfall for May, June, July, August, and September, was 8.89 inches. The total time spent in raising the crop, exclusive of harvesting, was 330 hours, including man and team for 25 hours.

As the experiment was carried out on a piece of most refractory soil, the cost of raising the crop would be no criterion for the judging of the cost of raising another crop under favorable conditions, therefore the details of cost are not given. The time given suffices to indicate that this particular crop could not yield a profit unless

we obtained a yield of upwards of 16 tons to the acre, and could sell it at four dollars a ton.

THE SUGAR IN THE CROP.

We began taking samples for the determination of the sugar content, and also for other purposes, on September 2, and took them weekly from that date until the crop was harvested, October 14.

The plot represents three well-marked soils; the extreme west end representing a fine loam, the middle a clay soil, with some gravel, and the east end a gumbo. The fine earth, or soil material, ranges between 91 and 95 per cent. It bakes badly, and the air-dried lumps require the use of a pestle to break them.

The varieties of beets planted were the Kleinwanzlebener, Vilmorin, Lion Brand, Lane's Imperial, and the Imperial—four rows each. We always took three samples of each variety, corresponding to the different kinds of soil. As a control, and for the sake of comparison, one sample each of the Kleinwanzlebener and Vilmorin was taken from the plots of the Farm Department.

Our object was to observe the time when the sugar is formed in the beet most rapidly; to study, in other words, the effect of the degree of maturity upon the sugar content, and to determine, if possible, what the effect of our bad soil conditions were upon both the formation and the amount of the sugar.

The soil is rich in potash and soda, with an ample supply of lime and a fair amount of phosphoric acid, but it is rather poor in nitrogen.

The sugar in this series of determinations was determined by means of Fehling's solution, and the percentages represent the total sugar. I have made no distinction between sucrose and the other sugars.

The numbers in the table represent the different soil conditions in our plot: Number one, for instance, always being taken along a line near the west end of the plot; number two along one across the middle, and number three near the east end. The stand in this, the east end, was very bad, and we could not adhere so strictly to a given line as at the other two points.

It must be acknowledged that the weekly average for the sugar content has but little value, still I have introduced it that a general view of the rate of increase may be more easily obtained.

TABLE SHOWING PERCENTAGE OF SUGAR.

Date.	Number.	Klein-wanzlebener.		Vilmorin.		Lion Brand.		Imperial.		Lane's Imperial.		Klein-wanzlebener.		Vilmorin.	
		Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.	Percentage of Sugar.	Purity.
September 2......	1	7.72	....	7.86	....	8.21	....	8.60	....	.....	....	8.36	....	7.24	....
	2	7.60	....	6.75	....	8.14	....	9.21	....	.....	....	.....	....	.....	....
	3	6.94	....	5.57	....	7.18	....	7.47	....	.....	....	.....	...	.....	....
Average	....	**7.75**	....	**7.06**	....	**7.84**	....	**8.43**	....	.....	....	**8.36**	....	**7.24**	....
September 8... ...	1	9.06	....	8.42	....	7.61	....	9.69	....	... .	....	10.60	....	9.98	....
	2	10.55	....	8.02	....	11.36	....	11.87	....	.....	....	.....	....	.....	....
	3	7.97	....	7.97	....	7.37	....	10.06	....	.....	....	.....	....	.....	....
Average	...	**9.19**	....	**8.14**	....	**8.78**	....	**10.54**	....	.....	....	**10.60**	....	**9.98**	....
September 15......	1	10.06	....	7.28	....	9.31	....	9.06	....	.....	....	8.55	....	9.73	....
	2	10.88	....	10.46	....	11.20	....	13.19	...	.....	....	... .	....	.. ..	....
	3	6.88	....	8.33	....	6.21	....	10.06	....	.....	....	.....	....	.....	....
Average	....	**9.61**	....	**8.69**	....	**8.91**	....	**10.77**	....	.....	....	**8.55**	....	**9.73**	...
September 22......	1	8.14	74	7.60	76	8.14	74	10.79	77	9.70	81	10.60	75	11.50	77
	2	10.73	76	10.73	83	10.02	77	10.85	72	10.73	77	.....	....	.....	....
	3	6.24	62	4.80	48	7.06	71	9.03	70	.....	....	.....	....	.....	....
Average	....	**8.37**	**71**	**7.71**	**69**	**8.41**	**73**	**10.22**	**73**	**10.14**	**79**	**10.60**	**75**	**11.50**	**77**
September 29......	1	9.91	76	8.69	72	12.49	89	10.36	74	.....	....	10.21	73	9.07	70
	2	10.42	80	9.03	70	10.36	....	11.42	71	.....	...	.....	....	.....	....
	3	8.07	58	6.85	49	7.86	60	7.24	66	.....	....	.....	....	.....	....
Average	....	**9.47**	**71**	**7.86**	**64**	**10.27**	**75**	**9.67**	**70**	.....	....	**10.21**	**73**	**9.07**	**70**
October 6..........	1	8.29	....	9.03	70	11.50	77	10.73	72	.....	....	12.15	81	10.02	72
	2	9.80	70	10.98	78	11.69	83	12.00	75	.....	....	.....	....	.....	....
	3	8.21	91	7.93	66	6.52	65	9.60	70	.....	....	.....	....	.....	....
Average	....	**8.77**	**80**	**9.31**	**71**	**9.90**	**75**	**10.78**	**72**	.....	....	**12.15**	**81**	**10.02**	**72**
October 13...	1	12.15	76	12.49	78	12.84	80	13.61	80	11.25	80	12.32	77	13.02	77
	2	14.70	82	10.13	72	13.61	76	15.20	84	9.91	....	.....	....	.....	....
	3	8.44	70	10.21	73	11.84	74	12.15	76	9.21	77	.....	....	.....	....
Average	....	**11.76**	**76**	**10.94**	**74**	**12.76**	**77**	**13.65**	**80**	**10.12**	**78**	**12.32**	**77**	**13.02**	**77**

The increase from September 2 to 15, inclusive, was positive in all cases. But the samples taken on September 22 show a falling off, which is not wholly regained by all the varieties until October 13. The cause of this is, I think, a rainfall amounting to .74 inch, which took place between September 10 and 14—mostly on the 14th. It did not produce a second growth. The beets were still

in such condition that they could continue their development without putting out new leaves, but they increased quite markedly in size, and the condition of their roots indicated plainly that they had taken on greater activity and were feeding vigorously. I think that the apparent falling off of the sugar content indicated a relatively greater increase in the other constituents than any decrease in the sugar. The average weight of the beets during this period corroborates this view. In cases where a second growth has taken place the results are unquestionably different, for then new leaves are put forth, and the supply of food stored is begun to be used up.

By the beginning of the second week in October the leaves began to turn yellow, and the plants showed signs of ripening. My opinion is, that it was rather a case of starvation than of natural maturing. The outside rows, in the case of every one of the varieties, and especially the ends of the rows, were much slower in showing these signs than the inside rows; further, the other plots on the Farm did not show the same signs of maturity for more than two weeks after this. The beets were all pulled on October 14.

A comparison of those samples numbered three throughout the table, with the others, gives an exaggerated view of the effect of very unfavorable conditions. I avoid saying alkalized soil, because I am by no means convinced that the effect, so evident in this case, is a direct result of the action of the alkali upon the plant. I am rather of the opinion that the same soil conditions, in the absence of alkali, would be quite as pronounced in their effect as that observed in this case. There is no reason why just as unfavorable conditions should not exist without the alkali; but, the fact remains that we have both in this instance.

The observable effects were, a very poor stand and small beets, having, for the most part, an exceedingly bad shape. The plants did not scald as I expected that they would, and as they did do in some parts of the plot. Whether this was due to a partial adaptation on the part of the plants, or due to other causes, I am unable to state. The appearance of the beets indicated that it was the former. The Kleinwanzlebener and Vilmorin, given as the sixth and seventh varieties in the table, are samples grown on good soil by the Farm Department, the Kleinwanzlebener on alfalfa sod. They were taken in order to have some comparable standard. They seem to have responded more quickly than my less favorably conditioned plot to the rain of September 14, and also to have gained in their sugar content rather sooner than mine.

I have included my sample number three in all of the weekly averages. This is perfectly proper, as the value attached to these averages, and the purpose of their introduction into the table, have been stated; but, in trying to form a judgment of the effect of alkali upon the sugar content of the beets, this sample ought to be excluded,

because the quantity of alkali was so excessive, or, as I believe, the other soil conditions were such that really no crop was grown. If it had been due to excessive alkali the samples numbered one ought to approach those numbered three much more nearly than they do, for the soil at this point carries much more soda, sulphuric acid and magnesia, with almost exactly the same amount of potash. In addition to these facts, the soil water in this portion of the field carries, at times, quite as much in solution as that from the east section, or section three, though the amount is usually less by from 10 to 80 grains per gallon. The water from the former carries from 150 to 200 grains per gallon, while that from the latter carries from 200 to 250. This subject of ground water will be treated of at another time.

The amount of alkali in the section represented by samples numbered one, being only slightly, if at all, less than in number three, but, the soil being in much better tilth, affords us better data on which to base our judgment.

The section represented by samples numbered one is in good condition and quite well drained, though it is on the western edge of this alkalized basin. Were it not for its proximity to the lower land it would be considered excellent, but an analysis shows it to contain more soda and sulphuric acid than the rest of the plot.

In order to judge of the effect of the alkali upon the sugar content in the beets, I think that we should take the Farm samples and numbers one and two, taken October 13. The crop had, at this date, reached its maturity—even the beets on the Farm plot, though remaining unharvested for a long time, showed only a moderate gain, not really large enough to positively place it beyond the differences in individual samples, after this date. In this case we observe that the Kleinwanzlebener, Vilmorin, Lion Brand, and Imperial, grown on my plot, and the Kleinwanzlebener and Vilmorin, grown on the Farm plots, are quite close, containing, in the order given, 12.15, 12.49, 12.84, 13.61, 12.32 and 13.02 per cent., while the samples from my plot numbered two, and taken in the same order, show 14.70, 10.13, 13.61, and 15.20 per cent. sugar. There is no room for question as to the character of the soils on which these samples grew. That on which the Farm samples grew, particularly in the case of the Kleinwanzlebener, is as free from alkali as any of our soil and was in good condition. The same is true in regard to the mechanical condition, though to a less extent, perhaps, of that on which my sample numbered one was grown, while that on which my sample number two grew was strongly alkalized, but the beets were richer in sugar than those grown on land practically free from alkali. This is true, also, of the samples taken on other dates, and of all the varieties, with few exceptions.

I conclude that the effect of white alkali, to the extent that it is present in this soil, is, of itself, not detrimental to the sugar beet, so far as its sugar content is concerned. This, though quite contrary to my preconceived notions, based upon previous but limited observations, is in harmony with the conclusions of Hilgard and Loughridge, who conclude, from their investigations made at Chino, California, that beets grown in soil carrying large amounts of alkali may be of good quality, both in regard to their purity and the percentage of sugar contained.

The causes of the low sugar content in the samples numbered three will be studied during the present season. It is evident from the uniformily low percentage of sugar and the low co-efficient of purity that there is some condition obtaining which is very harmful to the plant. Indeed, I am justified in making the statement, that in this section of the plot, the beets did not grow at all.

The table exhibits another interesting point, *i. e.*, the time of the most rapid increase of sugar in the crop, and how it may be influenced by the weather, and the condition of the crop at the time, for instance, of a rainfall. From September 2 to October 13 there is an increase of from three to five per cent., which is unevenly distributed throughout the six weeks, and much less evenly in my samples than in the Farm samples. Up to October 6, no marked increase in the percentage of the sugar had been observable. On the contrary, there had been fluctuations depending, as already pointed out, upon the weather and the condition of the crop. But, from October 6–13, there is a very marked rise in the percentage of sugar in five out of the six series, and a small increase in the sixth, which had shown an increase of about two per cent. during the preceding week. On October 6, the Kleinwanzlebener from the Farm plot, was the only variety yielding marketable beets, unless we include sample number two, of the Imperial. On October 13, however, there is only one sample falling materially below the standard of 12 per cent. This change, which we speak of as the maturing of the beet, makes a difference of from two to three per cent. My plot was harvested on October 14, and no opportunity was had to observe the deposition of the sugar subsequent to that time, but the Farm plots were not harvested until some days later, because they gave none of the accepted signs of ripening. I took another sample of the Kleinwanzlebener variety on October 21, and found 12.30 per cent., with a purity coefficient of 82.

This plot of beets had, according to our samples, been practically stationary in the percentage of sugar from October 6 to October 21, but the crop was increasing, at what rate I did not attempt to determine. Owing to the failure of this crop to ripen, *i. e.*, to show the usually accepted signs of ripening, a portion of it was allowed to remain in the ground, and was subsequently covered with straw to

protect the beets against severe freezing. A sample taken December 19 showed 12.7 per cent. of sugar, and co-efficient of purity 81. Another sample taken at the same time, and sent to Grand Island, Nebraska, showed, sugar 13.7 per cent., purity 86. My check on this showed, sugar 13.12 per cent., and purity 81. This is as close as can be expected, when it is considered that the samples were not parts of the same beets, and both had dried out to some, but probably to different, degrees.

On December 30, I took another sample and obtained, sugar 12.54 per cent., purity 85. The last of the beets were dug January 7, 1898, and showed 12.92 per cent. sugar. This is the average of eight beets tested individually. We see that, in this case, in which the variety was Kleinwanzlebener, taken from the same plot, we have a difference of less than 1 per cent. in the increase of the sugar from October 6 to January 8, but there is a positive increase, and it is not to be accounted for by the shrinkage in the crop. It would not be just to take the result obtained at the Grand Island factory as the maximum, because these beets had dried out to some extent. There is no question but that the determination is correct, but the sample was no longer representative.

I believe that this plot of beets represents the average sugar beet grown in this section of the state, and, so far as my observation goes, it represents the beets of the state. The average found by this Station from 1887–1896, inclusive, is 12.8 per cent. sugar, which is essentially the same as shown by the crops grown at the Station this year, and analyzed within a few hours after being pulled.

The time elapsing between the pulling of the beets and the making of the sugar determination, together with the care of the sample, is of the utmost importance. Indeed, there is no difficulty at all in making a most excellent showing for a very poor crop of beets.

THE DISTRIBUTION OF THE SUGAR IN THE BEET.

This question was raised incidentally during our study of the feeding value of the trimmings of the beets—that is, the tops of the beet removed. It has been claimed, and experiments made to show, that the percentage of sugar present in the beet increases from the top downward.

My time did not admit of my extending the series of analyses too greatly, so I have taken the larger sections, thirds, by weight. If there is any difference of sufficient magnitude to be of any practical importance, we should find it between the first and third thirds, numbering from the top downward.

The beets used were of the Kleinwanzlebener variety, freshly dug, and of medium size. The crown was not removed.

The sugar beet, with us, grows almost wholly under ground, and the question of crowns is of much less importance than in some other places.

SUGAR IN THE RESPECTIVE THIRDS.

	Thirds.	Percentage Sugar in Juice.	Percentage Sugar in Beets.	Total Solids in Juice.	Co-eff. of Purity.
Beet No. 1	1	12.70	12 07	14.660	87
	2	12.50	11.88	14.356	87
	3	12.30	11.64	14.312	86
Beet No. 2	1	13.30	12.64	16.646	80
	2	13.70	13.02	17.396	79
	3	13.90	13.21	17.596	79
Beet No 3	1	13.40	12.73	15.437	87
	2	13.80	13.11	16.185	85
	3	14.00	13.30	15.934	88
Beet No. 4	1	14.00	13.30	16.236	86
	2	14.40	13.68	16.352	88
	3	14.10	13.40	16.213	87
Beet No. 5	1	14.60	13.87	16.701	87
	2	14.30	13.78	17.155	85
	3	14.60	13 87	16.608	88
Beet No. 6	1	14.60	13.87	16.701	87
	2	14.60	13.87	16.701	87
	3	14.50	13.78	16.440	88

The sugar was determined by means of the polariscope, but no sample was repeated less than four times; besides, I checked my readings from time to time by means of test plates.

The specific gravity was determined by means of the Westphal balance. This series does not show any pronounced difference between the thirds, taken by weight. There is, in three cases, less sugar by 0.60 per cent. in the first one-third than in the third one-third, but in the other cases there is practically no difference. In taking the thirds by weight, the first one-third includes that portion usually trimmed off as objectionable, but neither the sugar content nor the co-efficient of purity shows any marked inferiority of this portion of the beet. I will anticipate a subsequent paragraph to the extent of stating that neither the amount of dry matter nor the percentage of ash indicates any reason why the crown should be much inferior to the rest of the beet. The averages for all the respective thirds show a difference of less than two-tenths of one per cent. of sugar in favor of the lower two-thirds of the beet. This is of some interest to our farmers, as they can market practically the full weight of their crop.

SUGAR IN THE CROWNS.

I, unfortunately, did not make the determination of the sugar in the crowns from perfectly fresh beets, but used beets which had been stored for a few weeks in the root cellar. I, however, got beets which had been covered with fine soil, and which was still as moist as it was at the time the beets were harvested.

By crown, or neck, I mean that portion of the beet between the base of the leaves and the transverse line, showing in a vertical sec-

tion of the beet, and transversing it from a point just below the outermost row of leaves.

The beets selected were, perhaps, rather above the average in size, and 14 in number. The average weight of the crowns, as determined from another similar lot of 22 beets, was 136.36 grams, or four and four-fifth ounces. This was about 13 per cent. of the beets. The sugar in the crowns was 15 1 per cent., with a co efficient of purity of 82.35; the sugar in the beets was 16.1, and the co-efficient of purity, 88. Six beets were u-ed in the sample for the sugar determination. The result, however, gives us a full answer to the question as to the sugar value of the crowns, *i. e.*, that it is about one per cent. less than that of the beet. While the statements in this paragraph agree with those made on this subject by others, in making both the percentage and purity somewhat lower than in the beets, my results make the difference much less than that given by others. Ware, in "The Sugar Beet," page 86, quotes Champignon and Pellet as making the difference 2.60 in the percentage of sugar. The Cornell University Agricultural Experiment Station Bulletin 143, makes the difference vary from 1.55 to 2.90 per cent. of sugar, and from 6 to 14 degrees in the purity. The crown, in this case, is really a structural portion of the beet, and not an indefinite part of the root, which has been exposed to the action of the light and air without protection, except that furnished by the foliage. The leaves being very heavy, furnish more protection to the beet grown here than is usual in other sections, but, aside from this, the sugar beet with us grows entirely under ground.

THE EFFECT OF FREEZING UPON THE SUGAR CONTENT.

I regret that my observations on this interesting point are not more extended. The samples in which the sugar was determined were frozen in the ground, but under a covering of straw or earth.

Sample No. 1—Upper third frozen; sugar in juice, 13.5 per cent.; sugar in beet, 12.82 per cent.;* purity, 78. The second third was not frozen; sugar in juice, 12.6 per cent.; sugar in beet, 11.98 per cent.; purity, 91. The bottom third not frozen; juice, 12.6; beet, 11.97 per cent. sugar; purity, 81.

Sample No. 2—Upper third frozen; sugar in the juice, 11.50 per cent.; sugar in the beet, 10.93 per cent.; purity, 73. Middle third frozen; juice, 11.7 per cent.; beet, 11.11 per cent. sugar; purity, 70. Bottom third not frozen; juice 15.1 per cent.; beet, 14.34 per cent. sugar; purity, 88.

Sample No. 3—Frozen solid; juice, 15.00 per cent.; beet, 14.25 per cent. sugar; purity, 84.

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* This solution being unsatisfactory, the sugar was redetermined by means of Fehling's solution, and showed 13.11 per cent. sugar in the beet.

Samples No. 1 and No. 2 were individual beets. No. 1 weighed $4\frac{1}{2}$ pounds, No. 2 weighed 2 pounds. The sample of this plot, taken October 13, contained 12.32 per cent. sugar, and samples taken later ran as high as 12.9. The average of these beets is 12.2 per cent., from which, it appears, that the sugar has suffered no diminution, while its redistribution in the beets is very marked.

Sample No. 3 was harvested October 29, and a part of the sample was placed in a shallow silo immediately, in order to avoid any loss of water due to direct exposure to wind and sun; the rest of the sample was taken to the laboratory and the sugar determined. The silo was opened December 19, and the beets found to be frozen hard. The sample analyzed, October 29, showed 14.03 per cent. of sugar, with a co-efficient of purity of 82, while the frozen sample of December 19, showed 14.25 per cent. of sugar, and a co-efficient of purity of 84.

Simple freezing does not cause any change in the sugar. This is an important consideration, or would become so, if our farmers were raising beets for a factory. If thawing could be prevented, the crop is not necessarily lost, if once frozen.

THE DRYING OUT OF BEETS.

I have already made incidental reference to this subject. It is of interest to both the producer and the manufacturer. I stated in a former paragraph that it is an easy matter to make a really poor crop appear to be a good one. It has, for years, been a cause of complaint that parties could always obtain better results from their samples by sending them to the Agricultural Department at Washington, than by sending them to their home Station. The Station undoubtedly gave them too high results in the great majority of cases, and the Department, at Washington, has been giving them still higher, and yet, both of them have been giving them correct results for the samples as analyzed; the samples, however, have not been representative of the crop as it stood in the field.

The Department, at Washington, has repeatedly called attention to this fact. Dr. Walter Maxwell, in his report to Dr. Wiley, records several series of experiments made with the object of determining the amount of this loss, which he gives, as varying from 16 to 26 per cent. for beets tied up in a sack, and kept from the wind and sun for a period of seven days, and from 23 to 35 per cent. for beets under normal exposure to air and sun for the same length of time. Dr. Maxwell makes the average loss, in the case of beets protected from the action of wind and sun, 20 per cent. in seven days.

It may be well to put this statement in a more concrete form, as we receive samples which have been pulled, or harvested, longer than this, and kept without any protection whatever. Assume that our sample, as received, weighs 40 ounces, and the juice shows a reading of 15 per cent., we report the sugar in the beet as 14.25 per

cent., showing the presence of 5.7 ounces of sugar. The amount of sugar given is correct, but the percentage of sugar in the beets is entirely too high, for the percentage is calculated on 40 ounces of beets, whereas, it should have been calculated on 50 ounces, and the percentage of sugar in the beets, as harvested, was only 11.4 per cent.

Dr. Wiley, in his report on the experiments with sugar beets in 1892, says:

"Again, the loss of moisture during transportation, or failure of the farmers to send their beets in as soon as harvested, may tend to reduce the amount of water present in the beet, and to raise correspondingly the quantity of sugar therein." In speaking of beets received from California, he says: "In this connection, however, it must be remarked that the beets were long in transit and must have lost a considerable quantity of water. They were somewhat wilted and shriveled in appearance when received. Such beets, of course, would indicate a higher percentage of sugar than they would really contain in a fresh state, and the same remark may be applied to the beets shipped any distance by mail, or to beets which have been exposed any considerable time to the air after harvesting, before the determination of the sugar." In speaking of the Colorado samples, he repeats the same, saying: "In regard to the content of sugar shown by these samples, the remark made with reference to California must be made here, viz., that the amount of sugar indicated on analysis is higher than that actually present at the time of harvesting, on account of the loss of water, during transportation."

These quotations are sufficient to show that the Department of Chemistry, at Washington, is fully aware of the error in the analysis of beets sent from this and other Western states, and no blame can, in any way, attach itself to them, because the figures given for the sugar in our beets is too high, by several per cent.—2.8 per cent. in the assumed case, which is far inside the facts.

This subject has a much wider bearing than the mere fact that determinations made, upon presumably identical samples, here and in Washington, do not agree. The Department of Chemistry has repeatedly warned the readers of its reports, that the figures are too high, and have given data by the aid of which an approximate correction can be made. I was not aware of Dr. Maxwell's experiments when I made mine, but I am gratified to find that the general results agree with his, though they differ in degree, owing, probably, to differences in the condition of the beets at the time of harvesting, the temperature, moisture of the atmosphere, etc.

My first experiments were made by taking two series of samples, wrapping the beets separately in paper, and placing them upon the cellar floor, which is the earth of the cellar, without covering. The light was very moderate. The samples were weighed, from time to time, during 17 days. A third sample was subsequently taken, but

the conditions were different; the beets were maturer and had lain several weeks in the root cellar before taken for this experiment, which was made in the laboratory. After the first two days the beets were wrapped up carefully, and covered with four thicknesses of gunny sacking, to protect them more fully from the light. The maximum temperature in the laboratory, during the experiment, was 69° F., and the average about 60° F.

LOSS OF WEIGHT DUE TO DRYING.

Experiment No. 1.

Date of Weighing.	Weight of Sample. Grams.	Total Loss.	Per Cent. Total Loss	Per Cent. Loss from Day to Day.	Remarks.
October 6............	2012	....	....	....	....
October 7............	1902	102	4.8	4.8	....
October 8............	1834	176	8.0	3.8	....
October 9............	1775	237	11.3	3.3	....
October 11............	1668	344	17 1	6.1	Average per day, 3.0......
October 13............	1584	428	21.2	5.0	Average per day, 2.5......
October 16............	1455	557	27.7	8.1	Average per day, 2.7......
October 18.	1392	620	30.8	4.3	Average per day, 2.1......
October 21............	1302	710	35.2	6.5	Average per day, 2.1......
October 23............	1240	772	38.3	4.7	Average per day, 2.3......

Experiment No. 2.

Date of Weighing.	Weight of Sample. Grams.	Total Loss.	Per Cent. Total Loss	Per Cent. Loss from Day to Day.	Remarks.
October 6............	1536	....	....	....	....
October 7............	1446	90	5.9	5.9	....
October 8............	1388	148	9.6	4.0	....
October 9............	1343	193	12.6	3.2	....
October 11............	1268	268	17.6	5.6	Average per day, 2.8......
October 13............	1197	339	22.1	5.6	Average per day, 2.8......
October 16............	1099	437	28.5	8.2	Average per day, 2.7......
October 18............	1052	484	31.5	4.3	Average per day, 2.1......
October 21............	987	549	35.7	6.2	Average per day, 2.1......
October 23............	945	591	38.5	4.3	Average per day, 2.1......

Experiment No. 3.

Date of Weighing.	Weight of Sample. Grams.	Total Loss.	Per Cent. Total Loss	Per Cent. Loss from Day to Day.	Remarks.
January 3............	5517	....	....	....	....
January 4............	5226	291	5.2	5.2	....
January 5............	4933	574	10.4	5.4	....
January 6............	4672	845	15.3	5.3	....
January 7............	4532	985	17.9	3.0	....
January 8............	4379	1138	20.6	3.4	....
January 9.	4258	1259	22.8	2.8	....
January 10............	4162	1355	24.5	2.3	....
January 11............	4055	1462	26.5	2.6	....
January 12............	3953	1564	28.3	2.5	....
January 13............	3853	1664	30.2	2.5	....
January 14............	3744	1773	32.1	2.8	....
January 15............	3649	1868	33.9	2.5	....
January 16............	3562	1955	35.2	2.4	....
January 17............	3487	2030	36.8	2.4	....
January 18............	3423	2094	37.9	1.8	....

The experiments agree in showing a loss of rather more than 38 per cent. in 17 days, and also quite a uniformity in the rate of loss, with the greatest irregularity during the first days of the experiments. The maximum of loss, for any single 24 hours, is 5.4 per cent. of the weight of the beets at the beginning of the 24 hours. It fell from this to about 2 per cent. for each 24 hours, where it remained. Dr. Maxwell made the loss equal to 20 per cent. of the original weight in seven days. I make it rather more, due, probably, to differences of conditions, but there is a substantial agreement between our experiments.

The farmer will appreciate these figures more fully, perhaps, when they are converted into other terms. They mean this to him, *i. e.*, if he has a crop of beets of 20 tons to the acre, and delays marketing them for 24 hours, he has lost one ton, or one twentieth of his crop, and if he delays a week he will lose one fifth of his crop, by weight. The percentage of sugar will be higher, but the tonnage less, by the amount of evaporation, whatever that may be.

It is evident that such large losses totally destroy the value of samples sent to the Station for analysis, unless great care is exercised by the sender, that the beets reach us in as fresh a state as possible, and if they are not quite fresh, the analysis has no value to either the sender or to anyone else. In illustration of this, I give the sugar content of the samples used in the experiments just detailed. A sufficient number of beets were taken from each lot, at the beginning of the experiments, to give us representative samples, and the sugar was determined in them while the samples were perfectly fresh. The sample used in experiment No. 1 contained 9.8 per cent., that used in experiment No. 2 contained 9.3 per cent., and that used in experiment No. 3 contained 14.4 per cent. of sugar. At the end of the experiments, the 9.8 per cent. of No. 1 had become 15.5 per cent., the 9.3 per cent. of No. 2 had become 12. 6 per cent., and the 14.4 per cent. of No. 3 had become 21.6 per cent.

The difference in percentage, shown in samples analyzed immediately after being pulled, and after exposure in the field for 24 hours, was almost exactly 1 per cent. This difference would make the average percentage in the beets from our plots 13.3 per cent. and 13.7 per cent., instead of 12.3 per cent. and 12.7 per cent., respectively.

THE LOSS OF SUGAR ON LONG DRYING.

This question is not of so great and immediate interest to the raiser, unless the factory should refuse to buy and hold the beets, but require the raiser to either hold them until the factory could work them up, or, in some way, make the raiser share the loss during storage.

The loss of sugar in the third experiment was quite significant, amounting to 1 ton in 14 tons of sugar, and this was with mature beets, kept 15 days; but the largest loss was observed in the second experiment, continued for 17 days, in which the loss of sugar amounted to 1 ton in every 6 tons. The loss of sugar in the beets used for the first experiment was quite small, amounting to only 1 ton in 40 tons. This question is, in all cases, of sufficient importance to deserve the attention of the factory people. It is not likely that such high losses, as occurred in experiment No. 2, would often be met with, because these beets were not mature, but those used in experiment No. 3, were such beets as would be readily marketable. This loss of sugar was not due to heating or fermenting, as the term would usually be understood by the farmer; there were no visible marks by which one would judge that any fermentation process had been going on.

I will state in detail the second and third experiments, lest some one should be confused by the two statements that there is a gain in the percentage of sugar caused by the drying out, and that there is also a loss of sugar. The original weight of the sample was 1536 grams, and the percentage of sugar 9.3 per cent., which gives us 143.0 grams of sugar; the weight of the dried-out beets was 945 grams, and the percentage of sugar was 12.6 per cent., which gives us 119.0 grams of sugar. We had, however, 143 grams of sugar to start with, and only 119.0 grams at the end, or a loss of 24 grams, a trifle over one sixth of the sugar present.

In the third experiment, the original weight of the sample was 5517 grams, and the percentage of sugar was 14.44. per cent., showing the presence of 796.59 grams of sugar; at the end of the experiment there remained 3423 grams of beets, having 21.57 per cent. of sugar, *i. e.*, there was only 739.3 grams of sugar, or 57.2 grams less than we had at the beginning; one fourteenth of that present in the fresh beets had disappeared.

These examples will suffice to illustrate the importance of this question, and, also, that there is a loss of sugar, while there is an increase in the percentage of the sugar in the beet.

THE YIELD OBTAINED.

The varieties of beets planted were five in number: Kleinwanzlebener, Vilmorin, Lion Brand, Lane's Imperial, and Imperial. The stand in parts of the plot was thick, and in, probably as much as two thirds of it, the stand was good, but in the other third it was exceedingly poor. The poor stand, in this part of the plot, was not wholly due to failure of the seed to come up, but partly to drowning out of the young plants, and partly to the action of the alkali. The plants were thinned to nine inches apart. It was necessary to let

them stand much longer before thinning than I desired, owing to the attack of insects, and to the dry weather. The beets, in the meanwhile, had grown so large that it was found impossible to pull the plants without serious injury to the ones we wished to leave, so we thinned them by cutting them out to the desired distance apart. The beets were harvested on October 14, and gave the following yields:

YIELD PER ACRE.

Variety.	*Tons Beets per Acre.*	*Tons Tops per Acre.*
Kleinwanzlebener	7.9	6.2
Vilmorin	8.6	7.9
Lion Brand	8.1	7.0
Lane's Imperial	15.9	7.1
Imperial	11.8	10.6

I learn from Prof. Cooke, in charge of the Department of Agriculture, that the yield of the College plots varied from eight to twelve tons per acre. It is clear that the yield from my plot does not vary enough from that of the other plots to justify the inference that the alkali had any influence upon the yield. The gross results, however, are not altogether conclusive, for the stand on the Farm plots was seriously affected by a spell of bad weather at planting time. My plot was sown at about the same time, and the stand was, on an average, poor enough, but other factors entered so largely into the question, that it is doubtful whether I would have had any better stand if the weather had been more favorable. The beets from the Farm plots were, as a rule, much finer beets, in shape and general appearance, than mine. I think that the coincidence, in the yields of the different plots, is accidental. The fact that they were grown under the same conditions, as to the weather, does not make them fully comparable.

RATIO OF BEETS TO TOPS.

Ware, in "The Sugar Beet," p. 93, says: "As a general thing, it is admitted that the weight of the leaves, in a given crop, is about equal to one half that of the roots, and one fourth to one third for beets containing 8 to 9 per cent. of sugar." Wiley, quoting from McMurtrie's Report, says: "Corenwinder and Contamine find that there is a relation between the size of the leaves and the richness of the roots; that roots which bear leaves of broad surface, are generally more rich in sugar than those having small leaves upon a contracted top, and these facts are confirmed by an analysis of subjects taken from the same field." At the same time, Deherain concludes, from his researches, that the weight of leaves of small beets is relatively greater than is produced by larger ones.

The tables, quoted both by Ware and McMurtrie, are given primarily to show that beets with heavy tops are richer in sugar than beets with lighter tops, and give us the ratio of the tops to the beets. It is for this purpose that I introduce them here:

Variety.	Per Cent. Sugar in Juice.	Weight of Roots, in Grams.	Weight of Tops.	Ratio Tops to Beets.	Per Cent. of the Beet.
Pink Top, 0	9.90	1393.0	281.0	1: 4.95	20.0
Pink Top, Enterre	10.18	984.0	375.0	1: 2.63	38.0
Improved, 1,093	14.42	863.0	531.0	1: 1.62	61.0
Improved, 927	14.78	787.0	531.0	1: 1.48	67.5

Other tables given, show that the weight of the leaves varies from 25 to 63 per cent. of the weight of the beets, and stress is laid upon the fact, that the sugar content increases as the ratio of the weight of the leaves to that of the roots increases.

The only other statement that I have been able to find, touching the relative weights of the tops and the roots, is given in Cornell University Station Bulletin 143, where it is shown to be, in one experiment, about 1: 5, or, more exactly, 20.29 per cent., and in another, 1: 3, or 35 per cent. These statements are not at all applicable to the beets grown in Colorado. The figures given on a previous page, under the caption of "The Yield Obtained," show that but one out of the five varieties yield 2 tons of beets to 1 ton of tops; in other words, that only one variety approached the rule, that the weight of the tops equals about one half the weight of the roots.

The figures given on the preceding page is for beets and tops trimmed as they would be for siloing, and not for factory use; if they had been, the Lane's Imperial would have given a much smaller weight of the beets, owing to their green necks, caused by their growing well out of the ground.

It is a patent fact, that the ratio of the weight of the leaves to that of the roots is less, at the time of maturity, than before this period, and that a study of this relation, prior to a reasonable development of the roots, would have no general interest. I began the study of this, and all the subsequent subjects, at the same time that I began to determine the sugar content of the crop, *i. e.*, September 2. The beets had already attained a fair size, the average weight of 93 beets, pulled on this date, being a trifle over 15 ounces, and the largest beets were always avoided. The sugar in the samples taken, on the respective dates, is given in the table under the caption, "The Sugar in the Crop."

RATIO OF LEAVES TO ROOTS.

Date.	Variety.	Number of Beets.	Weight of Tops. Grams.	Weight of Beets. Grams.	Ratio of Weight of Top to Weight of Beets.
September 2..........	Kleinwanzlebener	18	13111.7	9950.5	1:0.76
	Vilmorin	18	9273.6	6398.0	1:0.69
	Lion Brand...........	18	12832.7	7461.6	1:0.58
	Lane's Imperial	9	3218.5	5964.7	1:1.85
	Imperial	18	9152.1	5443.0	1:0.59
	Kleinwanzlebener No. 2...	6	4485.1	3898.2	1:0.87
	Vilmorin No. 2............	6	2789.6	2381.4	1:0.85
September 8.........	Kleinwanzlebener	12	8708.9	5261.6	1:0.60
	Vilmorin	15	8448.8	6962.7	1:0.82
	Lion Brand	14	9121.6	7805.2	1:0.85
	Lane's Imperial	11	5624.2	7756.4	1:1.27
	Imperial..................	15	8060.0	6668.6	1:0.82
	Kleinwanzlebener No. 2..	6	3487.1	3900.9	1:1.11
	Vilmorin No. 2............	2	1905.0	1474.2	1:0.77
September 15..........	Kleinwanzlebener	14	11475.8	8584.0	1:0.74
	Vilmorin	14	9253.2	8675.8	1:0.93
	Lion Brand................	12	7733.7	5057.5	1:0.66
	Imperial..................	14	11396.4	8447.9	1:0.74
	Kleinwanzlebener No. 2...	2	2336.0	2381.3	1:1.05
	Vilmorin No. 2............	2	1134.0	1564.9	1:1.38
September 22..........	Kleinwanzlebener	24	22021.8	15932.3	1:0.72
	Vilmorin	25	17864.0	17417.8	1:0.97
	Lion Brand	26	16635.4	12859.3	1:0.77
	Lane's Imperial...........	16	7683.4	13743.8	1:1.78
	Imperial...................	26	19106.3	13131.4	1:0.69
	Kleinwanzlebener No. 2..	2	861.8	1224.7	1:1.33
	Vilmorin No. 2...	2	1406.1	1247.4	1:0.86
September 29..........	Kleinwanzlebener	12	6005.9	7484.2	1:1.25
	Vilmorin..................	12	6395.7	6417.2	1:1.00
	Lion Brand...............	12	5896.7	5465.8	1:0.93
	Imperial	12	6373.0	6551.4	1:1.03
	Kleinwanzlebener No. 2..	2	1179.3	1247.4	1:1.00
	Vilmorin No. 2............	2	2404.0	3197.8	1:1.33
October 13............	Kleinwanzlebener.........	30	22180.4	22248.7	1:1.00
	Vilmorin...........	30	16147.7	19681.1	1:1.23
	Lion Brand................	30	17894.1	20991.6	1:1.17
	Lane's Imperial	30	11121.3	29316.7	1:2.55
	Imperial	30	17718.7	18665.2	1:1.06
	Kleinwanzlebener No. 2..	8	6576.8	7166.7	1:1.09
	Vilmorin No. 2............	8	4266.7	5802.7	1:1.35

The samples taken October 13 represent the mature crop for my plot, and, also, for the Farm plots, given in the table as Kleinwanzlebener No. 2, and Vilmorin No. 2. Omitting the Lane's Imperial, because of its exceptional ratio, and the fact that it grows out of the ground to a very considerable extent, whereas the others do not, we have the following figures, representing our sugar beets for the season of 1897: 136 beets grew 84784.4 grams of tops, equal

to 624.2 grams, 22 ounces, of leaves per beet. The roots weighed 94556.0 grams, an average of 695.2 grams, equal to 24.5 ounces. The ratio of the weight of the tops to the weight of the beets is as 1:1.12.

The ratio of the weight of the tops to that of the beets, for the same varieties, deduced from the weights taken in the field, was 1:1.14. The ratios for the five varieties deduced from the yield as given under that head, are as follows:

Kleinwanzlebener...	1: 1.274;	weight of tops = 78.5 per cent. of weight of beets
Vilmorin...........	1: 1.087;	weight of tops = 92.0 per cent. of weight of beets
Lion Brand.........	1: 1.157;	weight of tops = 86.4 per cent. of weight of beets
Lane's Imperial	1: 2.239;	weight of tops = 44.6 per cent. of weight of beets
Imperial	1: 1.113;	weight of tops = 89.8 per cent. of weight of beets

The tops and beets were both weighed while entirely fresh. The beets were taken and handled in such manner that we lost none of the leaves. In the other samples the leaves were taken at the base of the leaf, but none of the crown was taken. This was weighed with the beet. The change in the ratio of the leaves to the beets, by weight, is due to both the increase in the weight of the beet and to the decrease in the weight of the tops; the average weight of the leaves for one beet, on September 22, was 742; on October 13, 623.4 grams.

Persons familiar with the growth of the sugar beet elsewhere, remark, upon seeing ours, that they grow very vigorous tops. The weights corroborate the judgment. If the relative weights of the tops and beets were an applicable measure of the quality of our beets, they should be very good, indeed, and I believe them to be such; for I think that careful investigation will establish the fact, that it is a very good beet, which, in a perfectly fresh condition, will show a sugar content of 12.5 per cent. We have had individual beets, analyzed immediately upon being removed from the ground, to run as high as 15.5 per cent. sugar, but they do not all run that high, and an individual beet of high excellence does not make the crop excellent.

The ratio between the weight of the leaves and that of the roots of the sugar beet, as grown here, is so entirely different from that given for other localities, that we evidently cannot safely accept their data, as applying to our conditions. The same is true in regard to the size of the beets. I doubt whether a crop of sugar beets can be grown on ground, really suitable for their cultivation, with an average weight, per beet, of less than two pounds. But it does not follow that they will be low in percentage of sugar, or in purity. I have received, from time to time, several samples of large beets carrying a fair percentage of sugar, and of a satisfactory purity, one beet weighing about 5 pounds, which I analyzed simply because it was so large, carried 14.0 per cent. sugar, with a co-efficient of 88, and I re-

ceived three samples from another party, who excused himself for sending such large beets, but said that they were as near an average as he could get. The largest beet had been cut off at both top and bottom, so that there remained only the middle portion of the beet—this weighed 4.6 pounds. It was in excellent condition, the sugar present was 14.9 per cent., purity 81.2. The smallest beet weighed 3 pounds, and showed 12.1 per cent. sugar, purity 81.8.

These may give an idea of the exceptions to the general rules, as laid down for the sugar beet, with which we frequently meet. I do not know how the weight of the tops of these large beets compares with that of the roots, but evidently it must be less than in smaller beets. I have noticed in all of these cases that the crown is broad and full.

The observations were extended over a sufficient time, and enough of them made to give us conclusive data as to the relative weights of the tops and the roots, and also as to the rate of the increase of both, during the last six weeks of the season. On September 2, we find the average weight of the tops, for the four varieties of beets, *i. e.*, Kleinwanzlebener, Vilmorin, Lion Brand, and Imperial, to be 614.8 grams, or 21.5 ounces. We find the average for the tops of the same varieties, on October 13, 624.8 grams, or 22.0 ounces; in other words, the gain, if any, in the weight of the tops was very small, only one half ounce per beet; on the other hand, the average weight of the beet increased from 421.8 grams, or 14.9 ounces, to 695.2 grams, or 24.5 ounces—an increase of 9.6 ounces per beet, or 0.64 of its weight, on September the 2nd.

There is no material difference in the ratios for beets from the strongly alkalized ground, and from that practically free from it. The slight difference which exists shows the tops to be relatively heavier on the alkalized ground.

The maximum sugar content in the beets was reached as soon in the one case as in the other, and there was but a slight difference between the maxima. The weights of the beets and the percentage of sugar present at the various dates give us the rate of the deposition of the sugar. Both the increase in the crop and in the percentage of sugar, must be taken into consideration. In the case of our beets, it will be seen that, about one third of the sugar, in pounds per acre, was deposited between October the 6th and the 13th.* The same fact is observable in regard to the Farm plots, except that in the case of the Kleinwanzlebener variety, the increase in percentage, corresponding to the maturing of the plant, took place one week

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*The average weight of the beets on October 6 was 20.2 ounces, and the percentage of sugar was 10.15 per cent.

earlier. I was unable to discover any assignable reason for this. I thought, perhaps, the absence of alkali might be the cause, but a study of the ash of these beets made me abandon this idea, and I have no explanation beyond the record that it is a fact.

THE DRY MATTER IN THE BEETS.

The dry matter was determined in three sets of samples, taken at intervals of two weeks, beginning on the 2nd of September, and other determinations were made with samples taken as late as December 10. The number of beets has been taken as large as practicable, in order to obtain results from which the variation in the individual beets has been, for the most part, eliminated. This is quite necessary, as this variation amounts to as much as 8 per cent. in beets pulled on the same date and treated similarly. It is, of course, understood that the weight of the air-dry matter, in any organic substance, cannot be made with the same satisfactory sharpness that the moisture in an iron ore can be made. The statement that individual beets, of the same variety, and harvested on the same date, may vary as much as 8 per cent., is based upon carefully made determinations, and probably gives the range of the dry matter in sugar beets, *i. e.*, from 17–25 per cent. The dry matter in the fodder beets is much lower, and the statement just made is not applicable to them.

The table on page 31 exhibits the development of the dry matter in the crops grown on alkalized, and, also, on other ground. I have appended some determinations, made at later dates, and, also, of other varieties of beets, all grown on the College Farm.

The column of percentages shows, very clearly, the difference between the sugar beets and the larger growing stock beets. The latter containing about 14 per cent. dry matter, and the former 18 per cent.

In regard to the Lane's Imperial, it may be proper to state, that I know nothing about the history of the seed. While it may be a true Lane's Imperial, it is certainly not a good strain, and was evidently mixed. I do not mean that it was mixed by seed of other varieties being mingled with it, but had been grown from hybridized beets. This strain attained a maximum percentage of 10.14 per cent. of sugar early in the season, and did not increase materially in the percentage of sugar after September the 22nd.

The amount of dry matter in sugar beets grown on alkali soil is a little lower than in the other samples, the Kleinwanzlebener and Vilmorin marked No. 2. This seems to have been the case throughout the season. The difference, however, is not always in favor of the higher ground, and is not so decided as one could wish it to be in order to base a conclusion upon it. On October 13, for instance, the total dry matter in my samples ranged from 16.69–

18.01 per cent., while the two varieties grown on ground free from alkali, showed 17.5–18.8 per cent., the latter was the Kleinwanzlebener, from the Farm plot. But I am in doubt whether this higher figure is not an accident, as I obtained for beets from the same plot, December 10, only 17.48 per cent.; this, however, is a little higher than the same variety from my plot showed.

AIR-DRY SUBSTANCE IN SUGAR BEETS.

Date.	Variety.	Number of Beets Taken.	Weight of Green Beets. Grams.	Weight of Dried Beets. Grams.	Per Cent. of Air-dried Substance.
September 2..........	Kleinwanzlebener	12	5803.5	730.0	12.58
	Vilmorin..................	15	6092.6	675.5	11.08
	Lion Brand	14	7226.4	892.5	12.35
	Lane's Imperial	12	8777.0	775.5	8.84
	Imperial	15	4995.0	794.5	15.90
	Kleinwanzlebener No. 2..	5	3356.2	447.5	13.33
	Vilmorin No. 2...........	5	1942.4	283.0	14.62
September 22..........	Kleinwanzlebener.........	12	9377.9	1646.0	17.55
	Vilmorin............... ..	13	9956.3	1587.0	15.94
	Lion Brand............ .	14	7745.1	1373.0	17.73
	Lane's Imperial...........	16	10863.5	1458.0	13.42
	Imperial..................	14	7869.7	1400.0	17.79
October 13............	Kleinwanzlebener.........	18	15603.5	2605.5	16.69
	Vilmorin..................	18	13965.9	2385.0	17.08
	Lion Brand..............	18	15095.0	2718 5	18 01
	Lane's Imperial...........	18	18834.6	2686.0	14 24
	Imperial..................	18	12519.0	2228.5	17,80
	Kleinwanzlebener No. 2...	6	5715.2	1074.5	18.80
	Vilmorin No. 2............	6	4419.7	773.5	17 50
October 21............	Lane's Imperial...........	....	2640.0	373.0	14.13
	Large Pink Beets †........	....	8067.0	982.0	12.25
October 29............	Lane's Imperial...........	....	5500.0	739.8	13.45
	Long Red Mangoldwurzel	....	4500.0	641.6	14.28
	Yellow Globe.............	....	3850 0	536 3	14.63
December 10...........	Kleinwanzlebener No. 2...	6	7170.0	1241.5	17.48
	Vilmorin No 2 *...........	6	8364.0	1709.0	20.43

† The variety unknown. The seed was purchased as Lane's Imperial.
* This sample was taken from the root cellar, where it had lain about five weeks.

I have showed that about 17 per cent. of the crop is formed during the last two weeks of the growing season, also that about 33 per cent. of the total weight of the sugar was deposited during the last week or ten days, but we fail to observe any such increase in

the total dry matter of the crop. From September 22 to October 13, there is an average increase in the percentage of sugar present of, say, 3 per cent., and the crop increase was still greater; but the total dry matter is practically the same, only one variety showing an increase of 1 per cent., while another shows a decrease of almost as much, 0.86 per cent. The evident explanation is, that there is a transformation of some of the solids during this period. The following table gives the amount of this transformation between September 22 and October 13, for the four varieties of sugar beets grown on my plot.

THE AMOUNT OF DRY MATTER OTHER THAN SUGAR TRANSFORMED.

Date.	Variety.	Average Weight of Beets. Grams.	Per Cent. of Total Air-Dried Solid.	Per Cent. of Sugar.	Grams of Air-Dried Solids.	Grams of Sugar.	Grams of Solids Other than Sugar.	Per Cent. of Solids Other than Sugar.
September 22........	Kleinwanzlebener	781.50	17.55	8.37	137.15	65.41	71.74	9.18
	Vilmorin..........	765.80	15.94	7.71	134.10	59.04	75.10	9.08
	Lion Brand........	553.20	17.73	8.41	98.00	46.53	51.50	9.11
	Imperial..........	562.10	17.79	10.22	100.00	57.50	42.50	7.56
October 13..........	Kleinwanzlebener	866.80	16.69	11.76	144.80	103.30	41.50	4.79
	Vilmorin..........	775.90	17.08	10.94	142.50	84.90	57.60	7.42
	Lion Brand........	838.80	18.01	12.76	151.00	107.40	43.60	5.19
	Imperial..........	695.50	17.80	13.65	123.60	94.90	28.50	4.09

The same relations hold good for the percentage of total solids, not sugar, in the Kleinwanzlebener and Vilmorin varieties from the Farm plots on the 13th of October, as is shown in the above table for the other samples. They have been omitted because the data for September 22 were lost. The above series includes representatives of my whole plot, though, as I have pointed out elsewhere, a portion of the beets might, and perhaps ought to be, excluded, because of the excessive wetness and very bad tilth of the ground in which they grew. Still they do not obscure the general rule that there is a very materially less quantity of solids, not sugar, on October 13 than there was on September 22. It would be interesting to establish what this loss may be due to, and what the nature of the total solids, which disappear, may be.

The leaves have been supposed to play an important part in the formation of the sugar in the beet; indirectly they may, but I believe that the disappearance of the solids, not sugar, is the equiva-

lent, in weight, of the compounds already stored in the beet, and whose rapid change into sugar takes place at the maturation of the beet. There is only one other explanation which suggests itself to me; that is, that the ash constituents are either eliminated from the beet, or migrate to the leaves. This, however, is not the case. Fortunately, the answer is of such a character, that it matters not what the movement of the ash constituents in the plant may be, or whether elimination be taking place or not. The answer is simply this: The percentage of ash in the dry matter of the mature beet is not less than in the green beet, and the amount of ash in the beets on October 13, was greater than on September 22, which the following examples will show: On September 22 an average beet of the Kleinwanzlebener variety, contained 71.74 grams dry matter, not sugar, of this 9.92 grams was ash; on October 13 an average beet, weighing more than on the previous date, contained only 41.50 grams of dry matter, other than sugar, and of this 10.97 grams was ash. In the case of the other varieties, the amount of ash present on October 13 was either greater or practically equal to the amount present on September the 22nd; so the suggestion of elimination of ash has no weight. The weight of the leaves, per beet, is actually less on the ripe beet than on the green one. For instance, I found their weight about 120 grams per beet less, on October 13, than they were on September 22. This corresponds to an actual loss of dry matter, as the percentage of dry matter in the leaves is the same for the two dates, and the same is true for the percentage of ash; so there was an absorption of dry matter and ash constituents by the root during this period. The loss of weight in the leaves, green weight, is very nearly equal to the gain in weight in the beets. This may, in this case, be an accident, but, as it is the average of 105 beets, it is suggestive.

As I have not, up to the present time, examined the leaves for sugar, it is an open question whether this corresponds to the elaboration of sugar by the leaves. But, in consideration of the actual disappearance of dry matter from the beet, accompanied by an increase of the ash and sugar, I believe it points to the elaboration of formative compounds which pass into the beet, and are there transformed into sugar. The observations of Dr. Maxwell, on the deportment of soaked beets, would be easily explicable if this were the manner in which the sugar is formed, but otherwise one must subscribe to the doubt expressed by Dr. Wiley when he says: "The whole science of vegetable physiology and chemistry teaches that sugar is elaborated in the leaves of the beet plant by the condensation of formylaldehyde, which is produced by the action of the chlorophyl cell upon carbon dioxid and water. The beet itself has always been regarded simply as a storehouse, in which the elaborated sugar is conserved for the future use of the plant."

Dr. Maxwell's experiments are given in detail, and show that an actual formation of sugar took place in the beet during the seven days submergence. This seems, to me, to suggest the cause for the diminution of total solids, other than sugar, concurrent with the somewhat sudden increase in the amount of sugar present. It seems much more probable that so large an amount of sugar, as is developed within the brief period of ripening, should be produced from material already stored up in the beet, than by the activity of a dying leaf.

THE DRY MATTER IN THE RESPECTIVE THIRDS.

We have seen that there is only a slight difference in the sugar present in the respective thirds of the beet, taken by weight, and that this difference is so small and irregular that a large number of determinations would be required to establish its value. The same is true of the total dry matter in the beets. There is a small excess in the upper third. This varies in individual beets, but seems to be constant for the different varieties. The following table records the results:

Number of Beet.	Number of Third.	Kleinwanzlebener.		Vilmorin.		Average Per Cent. of Dry Matter.
		Oct 21. Per Cent. Dry Matter.	Dec. 10. Per Cent. Dry Matter.	Oct. 21. Per Cent. Dry Matter.	Dec. 10. Per Cent. Dry Matter.	
1	1	19.93	17.72	25.23	23.22	21.52
1	2	17.52	17.72	24.31	22.58	20.53
1	3	17.85	16.20	25.68	20.64	20.09
2	1	18.32	17.94	25.60	22.70	21.14
2	2	16.60	20.52	24.23	22.86	21.05
2	3	16.79	16.50	24.23	23.21	20.18
3	1	22.17	19.37	22.07	20.45	21.01
3	2	21.91	18.40	21.38	20.30	20.50
3	3	21.15	17.19	21.72	20.60	20.16
4	1	21.50	17.32	20.68	19.56	19.76
4	2	19.20	16.98	20.68	19.78	19.16
4	3	19.54	17.20	20.68	19.78	19.30
5	1	19.68	18.26	21.42	20.22	19.90
5	2	18.63	17.82	20.78	19.77	19.25
5	3	19.68	17.17	22.08	19.85	19.69
6	1	20.58	19.48	22.43	20.00	20.62
6	2	19.42	19.12	19.85	19.02	19.35
6	3	18.55	17.87	20.54	20.24	19.30

The average dry matter contained in these two varieties, on December 10, has already been given, as, 17.48 and 20.43 per cent., respectively, and the table corroborates the existence of a difference between the two varieties in this respect.

The quantity of dry matter is quite uniformily greater in the first third than in either of the others, while there is but little difference between the quantities present in the other two thirds. The dry matter, however, is so uniformly distributed throughout the beet that it requires the taking of the general average to make the law of its distribution evident. In an instance like this, the question, What does air-dry mean, ought to be anticipated. Determinations of moisture, in other samples, made by drying to constant weight, at the temperature of boiling water, showed an average water content of about 2 per cent. This determination is tedious, and somewhat unsatisfactory, but after trying the air bath at various temperatures I adopted the water oven, and heating to constant weight, as the most satisfactory.

Other varieties of beets, particularly stock beets, were experimented with and showed results identical with those recorded in the table, except, of course, that the percentage of dry matter is much lower.

THE MARC.

This is what is left of the beet after the sugar and other substances, soluble in water, have been removed. The extent to which the soluble portion of the beets is removed determines the percentage of marc. This percentage is assumed to be about 5 per cent. My samples were grated, or rasped, and washed with more care than can be given them on a manufacturing scale. and this, probably, is the reason that my figures are slightly below 5 per cent. This was not the case when the beets were simply sliced. The experiments were made to determine the effect of irrigation upon the amount of marc present; also, to study the ash constituents left in this by-product of sugar making.

The average of six determinations, using the Vilmorin variety, was 4.21 per cent.; the average of five determinations, made with the Kleinwanzlebener, was 4.38 per cent. Both of these series were raised with irrigation. Only one lot of beets, grown without irrigation, was tested to determine the marc, and this gave 5.25 per cent. I do not think that this result, though a large sample was taken, is conclusive that beets grown without irrigation really contain more marc than irrigated beets.

THE FODDER ANALYSES OF BEETS.

It is not my purpose to discuss the feeding value of either the roots or leaves of the beets. The value of the roots, for feeding purposes, is fully understood, as also the conditions under which

their feeding produces the most favorable results. The primary object of the analyses on page 37 was to discover the effect of the different soils upon the feeding value, and, at the same time, to study the differences due to varieties, if such should be discovered. The samples are parts of the larger samples taken on October 13, and which were used for the other data given throughout this bulletin. All data given for beets, taken October 13, are for the same general sample, and are comparable. The numbers, 1, 2, 3, have the same significance that they have in the table showing the amount of sugar, from week to week. 1, is good soil; 2, is good soil, quite rich in alkali; 3, is soil in bad tilth and rich in alkali, but no more so than 2. The analyses, given in the table, were made in duplicate, but averages are given to save space; the limits of variation allowed were 0.02 per cent. for nitrogen, 0.2 for the other determinations, except for crude fibre, for which 0.4 was admitted.

Analyses Nos. 1, 2, and 3, are of samples grown on excellent ground, and free from alkali. The analyses are intended as standards of comparison by which to measure the effect of our alkali. Analyses Nos. 19 and 20, are of leaves from the same beets, and are taken as standards of comparison for the leaves.

An examination of the table giving the percentage of sugar present in the beets, from the different sections of the plot, will show more clearly than the few percentages given, that the samples from sections Nos. 1 and 2, were quite as rich in sugar as those taken from the Farm plots, which we used as standards. But the samples from section No. 3 almost always showed a lower percentage of sugar. As stated elsewhere, section No. 2, of the plot, shows, upon analysis, more alkali per acre than the other sections, but its sugar content is uniformly high; therefore, I have left it as an open question whether the depression of the sugar percentage in the samples from section No. 3 was due to the alkali, or to general conditions with which the presence of the alkali has but little or nothing to do. This uncertainty is not present in these results. The beets grown on the alkalized soil contain more ash and more crude portein, and less nitrogen free extract. They are better beets for feeding, but not so good for sugar making.

The difference in the leaves is confined to a small excess in the percentage of ash in the samples from the alkali soil.

Analysis No. 10 is of a sample received from New Mexico. The soil on which it was grown is a fine prairie loam, and the sugar content, when received by us, was 17.25 per cent. Owing to the excellent character of the soil, and its richness in sugar, I used it as a futher standard, and it agrees, within quite narrow limits, with the samples from the Farm plots.

FODDER ANALYSES.

Sugar Beets.

Number.	Date.	Variety.	Section of Plot.	Moisture.	Ash.	Ether Extract.	Crude Portein.	Crude Fibre.	Nitrogen Free Extract.	Total Nitrogen.	Per Cent. of Sugar.
1	October 13.....	Kleinwanzlebener.....	Farm	1.325	5.510	0.317	6.429	7.212	79.207	1.029	12.32
2	October 13.....	Vilmorin..	Farm	1.662	5.469	0.378	8.578	8.515	75.398	1.372	13.02
3	October 29.....	Kleinwanzlebener.....	Farm	6.620	3.707	0.421	4.944	4.696	79.612	0.791	.....
4	October 13.....	Kleinwanzlebener.....	1	1.709	7.435	0.439	10.975	11.502	67.940	1.756	12.15
5	October 13.....	Kleinwanzlebener.....	2	1.319	6.491	0.674	9.391	7.427	74.698	1.501	14.70
6	October 13.....	Kleinwanzlebener	3	1.565	8.836	0.507	11.756	13.527	63.809	1.881	8.44
7	October 13.....	Vilmorin...	1	1.734	7.723	0.745	10.180	13.111	66.507	1.629	12.49
8	October 13.....	Vilmorin..............	2	1.897	6 561	0.721	9.689	8.054	73.078	1.550	10.13
9	October 13.....	Vilmorin............	3	2.879	7.109	0.300	8.586	6.164	74.962	1.374	10.21
10	....	Kleinwanzlebener *...	....	2.969	5.344	0.408	7.028	5.655	78.596	1.124	17.25
		Marc.									
11	November 8...	Kleinwanzlebener.....	Farm	1.490	4.542	0.272	5.541	23.122	62.033	0.886	.....
12	January 8......	Kleinwanzlebener.....	Farm	7.490	4.365	0.393	5.673	22.603	59 476	0.907	.....
13	January 8......	Vilmorin......	Farm	3.282	4.189	0.230	5.719	23.028	63.552	0.915	.....
		Fodder Beets.									
14	October 13.....	Lane's Imperial.......	1	2.035	7.239	0.360	6.789	5.999	77.578	1.086	11.25
15	October 13.....	Lane's Imperial.......	2	1.405	7.756	0.398	8 835	7.528	74 078	1.413	9.91
16	October 13.....	Lane's Imperial.......	3	2.130	9.361	0.480	10.487	11.552	65.990	1.678	9.21
17	October 21.....	Long Red Mangold....	Farm	1.313	7.280	0.422	6.172	6.033	78.780	0.987	.....
18	October 21.....	Large Pink...........	Farm	3.417	8.983	0.453	8.322	6.016	72.809	1.335	.....
		Leaves—Sugar Beets.									
19	October 13.....	Kleinwanzlebener	Farm	3.435	20.671	1.790	16.642	12.103	45.449	2.663	....
20	October 13.....	Vilmorin..........	Farm	2.477	26.429	3.066	18.781	12.425	36.822	3.005	.....
21	October 13.....	Kleinwanzlebener.....	1	3.621	24.849	2.567	16.142	10.884	41.937	2.582	.....
22	October 13.....	Kleinwanzlebener.....	2	2.371	27.850	2.666	17.221	10.665	39.227	2.755	.....
23	October 13.....	Kleinwanzlebener.....	3	2.299	27.000	2.521	21.560	11.648	34.972	3.450	.....
24	October 13.....	Vilmorin.............	1	3.298	25.049	2.505	16.509	12 261	40.378	2.641	.....
25	October 13.....	Vilmorin............	2	2.385	29.588	3.550	18.654	11.141	34.682	2.985	.....
26	October 13.....	Vilmorin.............	3	2.442	27.620	2.553	19.593	10.460	37.442	3.137	... .
		Leaves—Fodder Beets.									
27	October 13.....	Lane's Imperial......	1	2.544	27.639	2.708	13.715	12.852	40.542	2.194	.....
28	October 13.....	Lane's Imperial.......	2	2.530	31.052	3.652	15.722	11.737	35.307	2.516	.....
29	October 13.....	Lane's Imperial.......	3	2.825	27.932	2.199	18.893	11.706	36.445	3.023	.....
30	October 13.....	Chard's	....	2.382	22.533	1 495	12.546	11.206	49 835	2.007	.....

* Grown in New Mexico.

The difference between the beets from the two soils, will, perhaps, be more easily understood from the statement that the average ash and crude protein percentage in the beets grown on soil free from alkali, is 5.03 and 7.36, respectively, while they are 6.75 and 10.10 for these constituents in the other samples; the proteids are nearly 3 per cent. higher in the beets grown in the presence of the alkali.

The composition of the marc exhibits the fact that five sixths of the crude protein is removed by the diffusion, and about four fifths of the ash. The feeding value of the dry marc is, pound for pound, but a little inferior to the dry sugar beet, others make it slightly better. It may be safe to estimate it as about equal, but it must be kept in mind that it takes 400 pounds of dry beets, or one ton of green beets, to yield 100 pounds of dry pulp or marc.

The dry matter from the leaves is exceedingly rich in crude protein, and were it not for the large percentage of ash present would, doubtlessly, make a good fodder. The green leaves contain about 10 per cent. of dry matter, and 2.7 per cent. ash. I have had no experience in feeding green beet leaves, but it would seem to be a question whether the ingestion of so large an amount of ash constituents, largely potash and soda salts, would be beneficial.

The analyses of the fodder beets are interesting, but in estimating their value it must be remembered, that the fresh beet contains from 86–88 per cent. of water, against 79–82 per cent. in the sugar beet.

The chards were analyzed, purely as a matter of interest. I cultivated them in the hope that I would find them more effective in removing soda salts from the soil than the beets. I was disappointed; they did not endure the soil conditions nearly as well as the beets, and the dry matter in the tops contained less ash than the beet leaves. I expected them to produce an immense crop of leaves, but they did not. If success is to be attained by growing a heavy crop of foliage, rich in ash carrying much soda, some other plant than the chard must be chosen.

The percentage of crude fibre in the beets is very irregular, but is uniformly higher in the beets from the alkalized ground than in the others. In the leaves the contrary is noticeable, the percentage of crude fibre being quite constant. The nitrogen free extract is also quite uniform in quantity. The effect of the alkali is greater upon the composition of the beets than upon that of the leaves.

The increase in the proteids is probably due to the presence of nitrates in the ground water. The amount of nitrogen in the soils of my plot is small, varying from 0.04 to 0.065 per cent. The ground water, on the other hand, contains appreciable quantities of nitric acid. The amount of total solids in the ground water varies with the different wells, and at different times. The nitric acid, calcu-

lated as potassic nitrate, usually corresponds to about 0.20 per cent. of the total solids, often more, and sometimes much more.

The letters, A, B, C, D, in the following table, represent four wells at points 150 feet apart, on a line running through the centre of my plot; they are sunk to the gravel bed. E is a well to the east of my plot in a piece of ground which has been heavily fertilized with sheep manure, but is about 100 feet west of an underdrain; in other respects the following table explains itself:

POTASSIC NITRATE IN THE GROUND WATER.

	Date.	Total Solids per Million.	Percentage of KNO 3 in Total Solids.
Well A	July 12, 1897...............	4440.0	0.74
Well A.................	September 20, 1897	2789.1	0.32
Well B.................	September 20 1897	3985.7	0.16
Well C...............	September 20, 1897	2561.4	0.37
Well D................	September 20, 1897........	3407.1	0.37
Well F *...............	September 21, 1897	2187.0	0.83
Well E.........	September 20, 1897	807.1	0.092

* This sample was taken below the gravel in a newly opened well.

I have given the potassic nitrate in one set of samples taken about 23 days before the crop was harvested, which shows that the beets had access to an abundant supply of nitrates, and one greatly in excess of that present in the soil proper.

THE PERCENTAGE OF ASH IN THE BEETS.

The fodder analyses, given on a preceding page, indicate that the general effect of alkali is to increase the percentage of ash in the beets grown on ground affected by it. An attempt to establish this as a general fact, and to follow the accumulation of the ash in the beet plant, is recorded in the following paragraph.

The samples were carefully prepared for this purpose, and any exceptional percentages, appearing in the table, cannot be attributed to the presence of sand. The figures represent pure ash. The number of beets taken as a sample was usually four, in a few cases I took more. The leaves in every case correspond to the beets of that variety taken on the same date and from the same section of the plot.

PERCENTAGE OF ASH.

Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
September 2...	Kleinwanzlebener............	Farm	1.5166	5.3318	6.8484	0.9129	13.33
September 2...	Vilmorin................... ..	Farm	1.4190	5.9604	7.3794	1.0346	14.02
September 2...	Kleinwanzlebener............	1	1.5360	4 8770	6.4130	0.7913	12.34
September 2...	Kleinwanzlebener............	2	1.9090	9.1710	10.0800	1.3191	13.10
September 2...	Kleinwanzlebener............	3	1.7610	9.0640	10.8250	1.2806	11.83
September 2...	Vilmorin....................	1	2.0589	8.5761	10.6350	1.2007	11.29
September 2...	Vilmorin....................	2	2.0714	7.4660	9 5390	1.2961	13.59
September 2...	Vilmorin....................	3	1.8998	3.5569	5.4567	0.7187	13.17
September 2...	Lion Brand..................	1	2.3468	9.8608	12.2076	1.3380	10.96
September 2...	Lion Brand..................	2	2.1531	7.4155	9.5686	1.2583	13.15
September 2...	Lion Brand..................	3	2.0873	8.1086	10.1959	1.3479	13.22
September 2...	Imperial....................	1	....	....	9.0543	....	....
September 2...	Imperial....................	2	....	....	7.0858	0.8843	12.48
September 2...	Imperial....................	3	....	....	7.5097	1.2063	15.93
September 22..	Kleinwanzlebener....	1	1.2020	4.0616	5.2604	0.9952	18.92
September 22..	Kleinwanzlebener............	2	1.4228	5.0375	6.4603	1.2604	19.51
September 22..	Kleinwanzlebener.......	3	1.5416	8.4357	9.9773	1.3390	13.42
September 22..	Vilmorin....................	1	1.4072	6.6911	8 0983	1 2086	14.93
September 22..	Vilmorin....................	2	1.3492	5.5881	6.9373	1.2902	18.45
September 22..	Vilmorin....................	3	....	....	9.8277	1.3958	14.20
September 22..	Lion Brand..................	1	1.2450	5.5804	6.8254	1.2038	17.37
September 22..	Lion Brand..............	2	1.3322	4.1254	5.4576	1.1689	21.44
September 22..	Lion Brand..................	3	1.8732	8.1285	10.0017	1.6680	16.68
September 22..	Imperial....................	1	1.3129	6.2825	7.5954	1.2785	16.83
September 22..	Imperial....................	2	1.3198	4.9655	6.2853	1.3111	20.86
September 22..	Imperial	3	1.7768	6.9175	8.6943	1.3850	15.93
October 13.....	Kleinwanzlebener............	Farm	1.5768	3.9330	5.5098	1.0525	18.80
October 13.....	Vilmorin....................	Farm	1.3115	4.1579	5.4694	0.9572	17.50
October 13.....	Kleinwanzlebener............	1	1.5620	5.8727	7.4347	1.2792	17.26
October 13.....	Kleinwanzlebener............	2	1.3885	5.1026	6.4911	1.1742	18.09
October 13.....	Kleinwanzlebener.......... ...	3	1.5594	7.2770	8.8364	1.3350	15 11
October 13.....	Vilmorin....................	1	1.4230	6.2996	7.7226	1.2539	16.24
October 13.....	Vilmorin	2	1.4040	5.1560	5.5606	1.1439	18.96

PERCENTAGE OF ASH—(Continued.)

Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
October 13.....	Vilmorin.....................	3	1.3628	5.7462	7.1090	1.2204	17.17
October 13.....	Lion Brand..................	1	1.7794	4.8050	6.6044	1.2548	19.12
October 13.....	Lion Brand..................	2	1.4504	4.2645	5.7149	1.1132	19.49
October 13.....	Lion Brand..................	3	1.9505	7.7976	9.7481	1.3928	14.87
October 13.....	Imperial	1	1.4225	5.6254	7.0479	1.2672	17.98
October 13.....	Imperial.....................	2	1.2384	3.7372	4.9756	1.0866	21.84
October 13.....	Imperial.....................	3	1.9918	8.6668	10.6586	1.4495	13 60
September 2...	Marc, Kleinwanzlebener......	....	3.0214	1.3440	4.3654	....	....
September 2...	Marc, Kleinwanzlebener......	....	1.6100	2.6400	4.2500	....	....
September 2...	Marc, Kleinwanzlebener......	....	....	....	5.0700	....	....
November 11...	Marc. Kleinwanzlebener......	....	....	....	4.4600	0.2283	....
December 31...	Crowns, Vilmorin............	....	1.4188	3.1696	4.5884	1.1201	22.23
December 31...	Crowns, Vilmorin	....	1.1938	3.1358	4.3296	....	....
....	French Seed..................	N. M.	....	....	5.5280	1.1498	20.80
....	Kleinwanzlebener............	N. M.	....	....	4.4950	1.0910	24.27
....	Kleinwanzlebener............	N. M.	....	....	5.0020	1.0700	21.40
....	Kleinwanzlebener............	N. M.	....	....	6.2070	1.2960	20.88
....	Kleinwanzlebener............	Farm	....	....	5.2740	1.0070	19.09
....	Kleinwanzlebener............	....	....	....	5.3780	1.1430	21.25

Fodder Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. Ash.	Per Cent. Ash in Green Substance.	Per Cent. Dry Substance in Sample.
September 2...	Lane's Imperial..............	1	1.7773	10.2727	12.0500	0.9627	7.99
September 2...	Lane's Imperial..............	2	1.4668	8.4832	9.9500	0.9044	9.09
September 2 ..	Lane's Imperial..............	3	1.8504	13.1343	14.9847	1.3456	8.98
September 22..	Lane's Imperial..............	1	1.3232	8.2042	9.5274	1.2509	13.13
September 22..	Lane's Imperial..............	2	1.2995	7.0603	8 3598	1.1586	13.86
September 22..	Lane's Imperial..............	3	1.5112	6.7253	8.2365	1.1939	13.28
October 13.....	Lane's Imperial....	1	1.0732	6.1653	7.2385	1.1371	15.71
October 13.....	Lane's Imperial..............	2	1.2907	6.4652	7.7559	1.1370	14.66
October 13.....	Lane's Imperial..............	3	1.8025	7.5582	9.3607	1.1214	11.98
October 29.....	Lane's Imperial..............	Farm	0.9305	6.5277	7.4582	1.0031	13.45
October 29.....	Yellow Globe.................	Farm	1.0685	7.0353	8.1038	1.1855	14.63
October 29.....	Long Red Mangold..........	Farm	1.1811	6.8990	7.2801	1.0395	14.25
November 11..	Large Pink Beets............	Farm	1.1551	7.8267	8.9826	1.2692	14.13

PERCENTAGE OF ASH—(Continued).

Leaves—Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
September 2...	Kleinwanzlebener......	Farm	6.0100	18.9042	24.9142	3.3206	13.33
September 2...	Vilmorin	Farm	5.6108	22.8132	28.4240	2.4121	12.01
September 2...	Kleinwanzlebener............	1	6.1427	21.6657	27.9084	2.3206	8.35
September 2...	Kleinwanzlebener.......	2	5.7396	24.4700	30.2096	2.4680	8.17
September 2...	Kleinwanzlebener	3	4.8003	22.5977	27.3980	2.2581	8.24
September 2...	Vilmorin......................	1	4.8149	22.2602	27.0751	2.2174	8.19
September 2 ..	Vilmorin.....	2	5.6923	22.5583	28.2506	2.4493	8.67
September 2...	Vilmorin......................	3	5.7813	24.8516	30.6329	2 7630	9.02
September 2...	Lion Brand	1	4.8236	23.0358	27.8594	2.0805	7.47
September 2...	Lion Brand	2	5.3696	21.8552	27.2248	2.3557	8.65
September 2...	Lion Brand	3	5.7520	23.8686	29.6206	2.6373	8.94
September 2...	Imperial	1	5.6692	21.8643	28.5335	2.0800	7.29
September 2...	Imperial	2	5.9602	21.4842	27.4444	2.5495	9.29
September 2...	Imperial	3	5.5796	23.1323	28.8919	2.5713	8.90
September 22..	Kleinwanzlebener............	1	3.4194	19.2906	22.7100	2.0498	11.00
September 22..	Kleinwanzlebener............	2	3.3376	23.4965	26.8341	2.8559	10.64
September 22..	Kleinwanzlebener	3	3.7002	21.1696	24.8698	2.5049	10.07
September 22..	Vilmorin......................	1	4.7782	21.4531	26.2313	2.5732	9.81
September 22..	Vilmorin......................	2	4.0478	21.8570	25.9048	2.6099	10.07
September 22..	Vilmorin.....	3	4.0378	21.5575	25.5953	2.6448	10.33
September 22..	Lion Brand	1	3.2416	19.7522	22.9938	2.5293	11.00
September 22..	Lion Brand	2	3.9410	18.2716	22.2126	2.7654	12.45
September 22..	Lion Brand	3	4.0769	22.3222	26.3991	2.3830	9.03
September 22..	Imperial	1	3.3407	21.5265	24 8672	2.5737	10.35
September 22..	Imperial	2	3.8977	21.8771	25.7748	2.9460	11.43
September 22..	Imperial	3	5.4272	20.9275	26.3547	2.9754	11.29
October 13.....	Kleinwanzlebener............	Farm	3.0416	17.6298	20.6714	2.2283	10.18
October 13.....	Vilmorin......................	Farm	5.0199	21.4095	26.4294	2.8675	10.85
October 13.....	Kleinwanzlebener	1	3.3282	21.5212	24.8494	2.4395	9.82
October 13.....	Kleinwanzlebener	2	3.8774	23.9726	27.8500	3.0944	11.11
October 13.....	Kleinwanzlebener	3	3.5996	23.4004	27.0000	2 7081	10.03
October 13.....	Vilmorin......................	1	3.9930	21.0562	25.0492	2.5083	9.97

PERCENTAGE OF ASH—(Concluded).

Leaves—Sugar Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
October 13.....	Vilmorin	2	5.4476	24.1404	29.5880	3.3096	11.19
October 13.....	Vilmorin......................	3	4.2844	23.3354	27.6198	2.7192	10.10
October 13.....	Lion Brand....................	1	2.9932	20.3170	23.3102	2.6690	11.45
October 13.....	Lion Brand....................	2	4.1459	20.9634	25.1093	2.9829	11.84
October 13.....	Lion Brand....................	3	3.3740	21.5660	24.9400	2.3069	9.25
October 13.....	Imperial.......................	1	3.0633	22.6348	25.6981	2.7985	10.89
October 13.....	Imperial.......	2	3.8809	21.0601	24.9410	2.9729	11.92
October 13.....	Imperial.......................	3	3.6136	22.5378	26.1514	2.1574	8.25

Leaves—Fodder Beets.

Date Harvested.	Variety.	Section.	Per Cent. Insoluble Ash.	Per Cent. Soluble Ash.	Per Cent. of Ash.	Per Cent. of Ash in Green Substance.	Per Cent. of Dry Matter in the Sample.
September 2...	Lane's Imperial.........	1	8.0789	24.9496	33.0285	2.9824	9.03
September 2...	Lane's Imperial..............	2	4.5602	25.7718	30.3320	2.4144	7.96
September 2...	Lane's Imperial.........	3	7.1726	28.8794	36.0328	2.8393	7.88
September 22..	Lane's Imperial..............	1	4.2517	23.7127	27.9644	2.6901	9.62
September 22..	Lane's Imperial..............	2	5.8499	24.8072	30 7591	3.0573	9.94
September 22..	Lane's Imperial..............	3	4.8015	23.3716	28.1731	2.4961	8.86
October 13.....	Lane's Imperial..............	1	4.9276	22.7118	27.6394	2.6094	9.04
October 13.....	Lane's Imperial.....	2	5.5246	25.5276	31 0522	3.2668	10.52
October 13.....	Lane's Imperial..............	3	4.8318	23.0998	27.9316	2.6513	9.42
September 29..	Chards.........................	1	3.1350	17.7539	20.8889	2.1866	10.47
September 29..	Chards	2	4.0638	18.4694	22.5332	2.5937	11.51
September 29..	Chards.........................	3	3.2086	20.6892	23.8978	2.1787	9.12
October 13.....	Chards.........................	....	3.2600	19.2730	22.5330	2.3231	10.31

The table shows that by the 2nd of September, more than one half, and less than two thirds, of the total ash taken up by the roots, has already been accumulated—stated a little more explicitly, about 58 per cent.—while the leaves have stored up about 70 per cent. of the ash contained in them at maturity. The deposition of the greater part of the ash takes place earlier in the leaves than in the roots, but continues in both until the time of ripening, or maturing of the beet. I took no samples of leaves for analysis subsequent to

October 13, but I have elsewhere stated what I mean by the maturing of the beet. The percentage of ash in the fresh roots is seen to slightly decrease with the advancement of the crop; this is due to the rapid increase in the weight of the crop itself, and not to an elimination of the ash constituents. The mature beet, as grown here, contains a trifle over 1.10 per cent. of ash, and the leaves contain a little more than twice as much.

The table also shows clearly the influence of the alkali in the soil upon the percentage of ash, *i. e.*, that it causes an increase of about 2 per cent., reckoning the ash on the dry matter. The results are quite in harmony with those previously given, except that the percentage of ash in the beets grown on alkali soil is still greater than shown by the fodder analyses. The actual percentages for beets grown on good ground and on alkali ground are 5.32 and 7.58, respectively. The varieties of soils within the plot itself, indicated by the figures 1, 2 and 3, show no such evident effect, and there is no regularity in the variations of the percentage of ash in the samples from these sections. The beets from section 3, especially in the latter part of the season, show a higher percentage of ash than the samples from the other two sections. The samples from this section are lower in percentage of dry matter, also in the percentage of sugar, but higher in percentage of proteids, than the others. This is the wettest portion of the plot, and shows, during either cold or dry weather, an abundant efflorescence of alkali, but the analyses of the soils do not show that it contains more, or even as much, as section 1. The corroding effect of the alkali was scarcely noticed at all in this (the 3rd) section, while it was observed in the 2nd. This may be due to the character of the salts in solution, and not to their quantity; still, the total alkalies in section 2 is greater, apparently, than in section 3. The effect of the alkalies upon the tilth of this ground is not clear to me. The soil in this section is so saturated with calcic sulphate that small aggregations of gypsum crystals are plentiful in some portions of it. The tilth is very bad, but whether this is due to the water, and the fineness of the soil, or in any larger measure to the alkali, which is practically sodic sulphate, may be an open question, but I am quite convinced that the alkali has comparatively little effect, directly or indirectly, in determining the character of the beets in this case. The effect of the crop upon the soil was little, or nothing.

It has been shown that the leaves of the sugar beet plant, as it grows with us, are equal to from 70 to 90 per cent. of the weight of the roots. The percentage of ash in the green substance shows that ton for ton, the leaves remove from two to two and one fourth times as much ash material as the roots. I had hoped to find in this ratio,

and the tolerance of the beet plant for alkali, a means of keeping down, or removing, considerable quantities of alkali from the soil, especially as I hoped to find that the plant would, in the presence of so large a supply of soda salts, take up a large percentage of them. I expected to find this the case in both the roots and leaves—to a greater extent, of course, in the leaves than in the roots. It was with this idea that I planted chards, but I was disappointed in the results of this experiment, for they made no such crop of leaves as they should have made, and they were not as high in percentage of ash as the leaves of the beets. The experiment with the chards was so evidently a failure, in regard to its primary object, that I practically abandoned it.

The table also contains the results obtained from fodder beets. The crop of roots is usually very much larger, while the percentage of ash in the fresh crop is rather less. In regard to the leaves, their ratio, by weight, to the roots being much lower, amount to about the same on a basis of 2 tons of fodder beets to 1 ton of sugar beets. The percentage of ash is quite the same in the two classes, and the mineral constituents removed by such crops would be about equal. The roots of a crop of fodder beets removes, because of their high tonnage, from two to three times the amount of ash constituents that is removed by a crop of sugar beets.

THE DISTRIBUTION OF THE ASH IN THE BEET.

The sugar and dry matter in the respective thirds of the beet, numbered from the top downward, have been given. Two series of experiments were made with the Kleinwanzlebener and Vilmorin varieties, to see whether we could establish any difference between the ash content of the thirds, and also its value. The series consisted of six beets each; the Kleinwanzlebener samples were freshly dug, but the Vilmorin sample was taken from the cellar. The average percentage of sugar in the Kleinwanzlebener variety was 12.70 per cent.; in the Vilmorin, 14.90. The percentage of dry matter in these series is given in detail under the caption, "Distribution of the Dry Matter in Beets," where it is shown that there is a little more in the first third than in either of the other thirds, but that the difference is very small, varying from three tenths to one per cent.

Variety.	Series.	Thirds.	1		2		3		4		5		6	
			Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.	Per Cent. of Ash.	Per Cent. of Ash in Fresh Beet.
Kleinwanzlebener..	No. 1	1	5.53	1.10	5.83	1.07	5.17	1.15	4.25	0.91	6.48	1.28	4.63	1.05
		2	5.68	1.00	6.36	1.06	5.33	1.17	5.36	1.03	6.27	1.17	5 69	1.10
		3	5.90	1.05	6.63	1.11	5 70	1.21	5.46	1.07	6.05	1.19	6.78	1.26
	No. 2	1	5.91	1.05	5.78	1.04	4.95	0.96	7.67	1.33	5.59	1.02	4.50	0.88
		2	5.90	1.04	5.67	1.16	5.11	0.94	6.84	1.16	5.37	0.96	4.17	0.80
		3	6.44	1.04	4.93	0.81	5.84	1.00	6.50	1.12	5.69	0.98	4.88	0.87
Vilmorin..	No. 1	1	4.95	1.25	4.10	1.05	4.36	0.95	5.46	1.13	6.12	1.31	5.29	1.19
		2	4.32	1.05	4.54	1.10	4.19	0.90	5.12	1.06	6.11	1.27	5.96	1.18
		3	4.57	1.17	4.71	1.14	4.61	1.00	5.71	1.18	5.97	1.32	6.63	1.36
	No. 2	1	5.28	1.23	5.17	1.17	6.21	1.27	7.04	1.38	6.86	1.39	7.10	1 42
		2	4.85	1.10	5.31	1.21	6.48	1.22	6.77	1.34	6.35	1.26	7.10	1.35
		3	5.35	1.10	5.47	1.27	6.69	1.38	6.86	1.36	6.71	1.33	6.95	1.41
Lane's Imperial ...	......	1	7.64	1.09	5.77	1.06	7.56	1.13	......	......	......	......	......	......
		2	7.25	1.01	4.92	0.85	5.53	0.82	......	......	......	......	......	......
		3	7.35	1.04	4.83	0.82	5.77	0.86	......	......	......	......	......	......
Large Pink	......	1	9.53	1.20	9.44	1.25	......	......	......	......	......	......	......	......
		2	8.91	1.07	11.03	1.27	......	......	......	......	......	......	......	......
		3	8.56	1.03	12.46	1.42	......	......	......	......	......	......	......	......

An inspection of the results obtained upon individual beets, leaves the impression that there is a larger percentage of ash in the third, or lower one third, than in the others, which is really the case, but it is much less decided than appears from a simple inspection of the table. The averages, taken by series, is as follows:

Variety.	Thirds.	Series I.		Series II.	
		Per Cent. of Ash in Dry Matter.	Per Cent. of Ash in Fresh Beets.	Per Cent. of Ash in Dry Matter.	Per Cent. of Ash in Fresh Beets.
Kleinwanzlebener......................	1	5.31	1.09	5.71	1.05
	2	5.78	1.09	5.51	1.01
	3	6.09	1.13	5.70	0.97
Vilmorin..............................	1	5.05	1.15	6.27	1.31
	2	5.04	1.09	6.14	1.25
	3	5.37	1.19	6.24	1.31

Taking the averages of all the respective thirds in their order, we have, for the first third, 5.59 per cent. ash in the dry material, 5.61 per cent. for the second, and 5.85 per cent. for the third, or bottom third. This appears to prove that the percentage of ash increases in the lower portion of the beets. We have already seen

that the sugar is a little higher in the lower two thirds than in the upper third, *i. e.*, first third contained 13.08 per cent. sugar, the second 13.22 per cent, and the third 13.19 per cent. sugar. According to this, the percentage of both the ash and sugar increase in the lower part of the beet. If, however, we take the percentage of ash in the fresh beet, which seems to me the proper basis, the matter stands differently in respect to the ash, *i. e.*, it is greater in the first third, and diminishes in the lower portions of the beet, for we have them in the thirds, beginning at the top, 1.15, 1.09, 1.05 per cent. In either case the difference is much less than I had hoped and expected to find. A concrete statement will possibly make the smallness of this difference plainer to some readers. It means, that, if we had a crop of sugar beets, of 15 tons to the acre, and divided every beet into three equal parts, by weight, there would be, in the five tons of upper thirds, ten pounds more of ash than there would be in the five tons of lower thirds.

The percentage of ash given for the dry matter is misleading in this, that it gives no statement of the fact that the percentage of dry matter is greater in the first third of the beet. If we take this into account, we find, on calculating the ash, for the assumed crop of 15 tons to the acre, that there is practically no difference. We get 116.22 pounds in the first third, and 115.77 pounds for the third, or lower third, of our crop. Both methods of calculation lead to the same conclusion, *i. e.*. that the ash in the beet root is quite evenly distributed throughout the beet, with a slight excess in the upper portion of the root, but the percentage of ash is greater in the dry matter of the lower third.

THE COMPOSITION OF THE ASH.

It was my expectation, when this work was planned, to find in the composition of the ashes, particularly of the leaves, a means of removing large enough quantities of soda salts to ameliorate the alkaline condition of the soils, as we find it in Colorado.

The ashes were prepared with care, but it seems to be a difficult task to prepare them so that no organic matter shall be left. The sample was, in every case, first charred, the soluble ash thoroughly washed out, and the carbon then burned out of the residue. The ash of the whole sample was mixed with ammonic carbonate, and heated to 200° C., for two hours.

The portion of ash, insoluble in water, is very variable, especially in the beets. In the leaves it is higher in early September than subsequently, and always lower by 2 or more per cent. of the total ash, than in the roots.

In the following table is given the composition of the ashes of samples taken at three different periods of development, which may be best judged of by the dates on which the samples were taken. With the composition of the ash we complete the data concerning

the samples. The same samples were used for the estimation of the sugar, the dry matter, the fodder analysis, and for the work on the ash. For instance, the sample of Kleinwanzlebener, taken on October 13, was taken large enough to furnish material for the different determinations. The data obtained gives a complete history of the plant's development. I may state that 1,200 pounds of beets, and nearly as many tops, were used during the course of this investigation, the object being to obtain results which would be representative.

The plan was to study each of the varieties planted, but I have been compelled to confine the study to the Kleinwanzlebener. I have taken two as comparative standards, the Kleinwanzlebener and Vilmorin. I gave up my original plan the more willingly, as the examination of the one series shows so great a uniformity in composition, that there is no evident object to be gained which is nearly commensurate to the work involved. I give the direct results of the analyses, believing that they convey a sufficiently clear idea of the composition of the ash to the general reader, while the chemist, or other person, who wishes to reduce the terms to another basis, can easily do so.

The following tables have been grouped together so as to present the condition, and the effect of the variety of soil, without further explanation. In the first table I have given the analyses of the ashes which I assumed to be representative of good soils, to which I have added an analysis of the ash of the marc, from Kleinwanzlebener beets, grown on the Farm plot, and corresponding to the analysis given in the first column:

	Kleinwanzlebener.	Kleinwanzlebener.	Vilmorin.	Marc.
Sugar Content in Beets........ ...	12.32 per cent.	17.25 per cent	13.02 per cent.	12.90 per cent.
Where Grown.....................	Farm Plot.	New Mexico.	Farm Plot.	Farm Plot.
Carbon..........................	None.	None.	Trace.	None.
Sand............................	0.699	1.212	0.931	15.671
Silica..........................	1.196	1.506	1.264	4.787
Sulphuric Acid..................	3.481	2.777	2.878	1.622
Phosphoric Acid.................	8.607	3.336	6.088	3.283
Carbonic Acid...................	20.214	18.213	19.177	23.807
Chlorin.........................	5.686	12.500	10.887	0.155
Potassic Oxid...................	32.334	39.639	40.065	14.802
Sodic Oxid	17.888	9.940	11.161	3.711
Calcic Oxid.....................	3.257	3.458	3.409	15.790
Magnesic Oxid...................	6.065	7.024	5.264	9.768
Ferric Oxid.....................	0.286	0.468	0.414	1.300
Aluminic Oxid...................	0.268	0.232	0.774	0.848
Manganic Oxid (brown)...........	0 298	0.361	0.186	0.364
Loss on Ignition................	1 272	2.073	....	[4.126]
Sum.............................	101.544	102.739	102.498	100.034
Oxygen equivalent to Chlorin....	1.281	2.817	2.441	0.034
Total...........................	100.263	99.922	100.057	100.000

ASH OF THE SUGAR BEET IN ALKALI SOIL.

Harvested September 2.

	Section 1.		Section 2.		Section 3.	
	Beets.	Leaves.	Beets.	Leaves.	Beets.	Leaves.
Carbon	None.	Trace.	Trace.	Trace.	None.	Trace.
Sand	1.830	4.484	1.892	1.859	1.417	1.549
Silica	1.680	3.154	1.744	2.319	1.957	2.883
Sulphuric Acid	3.212	3.369	3.191	3.612	3.098	2.261
Phosphoric Acid	6.433	2.167	8.758	2.212	7.201	2.823
Carbonic Acid	14.495	12.632	14.817	14.484	16.381	15.991
Chlorin	13.779	20.729	12.315	18.219	11.326	18.000
Potassic Oxid	36.477	21.260	39.832	23.170	32.820	19.657
Sodic Oxid	15.755	23.901	12.130	24.381	19.220	28.577
Calcic Oxid	1.740	2.667	1.190	2.137	1.216	1.661
Magnesic Oxid	4.485	6.577	4.100	7.132	4.474	5.916
Ferric Oxid	0.590	0.652	0.581	0.464	0.682	1 119
Aluminic Oxid	0.276	0.512	0.370	0.330	0.339	0.498
Manganic Oxid (brown)	0.142	0.086	0.133	0.121	0.168	0.128
Loss upon Ignition	2.328	3.095	1.614	5.693	1.994	2.768
Sum	103.222	105.185	102 667	104.123	102.293	103.831
Oxygen equivalent to Chlorin	3.105	4.673	2.775	4.105	2.552	4.056
Total	100.117	100.512	99.892	100.018	99.741	99.775

Harvested September 22.

	Section 1. Beets.	Section 1. Leaves.	Section 2. Beets.	Section 2. Leaves.	Section 3. Beets.	Section 3. Leaves.
Carbon	None.	Trace.	Trace.	Trace.	None.	None.
Sand	0.665	0.538	0.868	0.139	0.610	0.700
Silica	0.858	1.024	0.855	0.651	0.931	1.933
Sulphuric Acid	3.949	3.821	3.612	3.281	2.550	2.976
Phosphoric Acid	7.906	2.286	8 786	1.902	7.688	3.133
Carbonic Acid	16.467	12.528	14.758	10.760	16.471	16.117
Chlorin	11.493	24.923	12.826	27.781	14.408	21.349
Potassic Oxid	36 780	20.738	41.620	28.225	34.895	21.572
Sodic Oxid	13.434	27.608	9.744	22.863	18.637	27.859
Calcic Oxid	2.826	2.699	2.180	2.295	1.254	1.841
Magnesic Oxid	5.783	5.731	5.512	5.110	4.028	5.770
Ferric Oxid	0.309	0.179	0.310	0.058	0.290	0.502
Aluminic Oxid	0.158	0 170	0.156	0.206	0.103	0.395
Manganic Oxid (brown)	0.190	0.139	0 214	0.155	0.114	0.161
Loss upon Ignition	1.690	3.511	1.842	3.261	1.624	....
Sum	102.408	105.895	103.283	106.687	103.603	104.308
Oxygen equivalent to Chlorin	2.590	5.616	2.890	6.265	3.246	4.811
Total	99.818	100.279	100.393	100.422	100.357	99.497

ASH OF THE SUGAR BEET IN ALKALI SOIL—(Concluded).

Harvested October 13.

	Section 1.		Section 2.		Section 3.	
	Beets.	Leaves.	Beets.	Leaves.	Beets.	Leaves.
Carbon	Trace.	None.	Trace.	None.	None.	None.
Sand	0.822	0.408	1.188	0.314	0.497	0.394
Silica	1.144	0.842	1.102	0.758	0.941	0.960
Sulphuric Acid	3.585	3.803	3.476	3.859	3.400	3.580
Phosphoric Acid	8.049	2.051	8.668	1.793	7.504	2.317
Carbonic Acid	14.051	10.628	15.690	10.940	16.734	14.848
Chlorin	14.961	28.511	12.599	27.766	13.561	23.289
Potassic Oxid	38.966	23.780	42.976	25.718	37.491	23.838
Sodic Oxid	12.828	25.375	8.811	22.324	16.123	25.515
Calcic Oxid	2.101	2.437	1.951	2.527	1.331	1.537
Magnesic Oxid	5.339	6.000	5.573	6.169	4.791	5.624
Ferric Oxid	0.815	0.125	0.146	0.128	0.276	0.062
Aluminic Oxid	0.213	0.113	0.538	0.123	0.400	0.173
Manganic Oxid (brown)	0.183	0.068	0.195	0.137	0.197	0.106
Loss upon Ignition	....	2.943	....	4.054	....	3.421
Sum	103.057	107.084	102.912	106.610	103.246	105.664
Oxygen equivalent to Chlorin	3.166	6.425	2.839	6.257	3.057	5.226
Total	99.891	100.659	100.073	100.353	100.189	100.438

ASH OF FODDER BEETS.

	Lane's Imper'l.	Yellow Globe.	Long Red Mangold.	Large Pink.
Where Grown	Farm	Farm	Farm	Farm
Carbon	None.	Trace.	None.	None.
Sand	0.237	0.597	0.216	0.725
Silica	1.044	0.857	0.594	1.052
Sulphuric Acid	3.900	2.189	2.832	2.597
Phosphoric Acid	4.605	6.547	5.232	6.209
Carbonic Acid	23.344	16.949	21.447	21.871
Chlorin	7.813	16.827	9.628	9.252
Potassic Oxid	33.474	38.620	38.787	27.656
Sodic Oxid	21.465	14.559	16.151	24.397
Calcic Oxid	2.015	1.909	2.661	1.992
Magnesic Oxid	3.270	3.189	3.274	3.262
Ferric Oxid	0.191	0.497	0.175	0.254
Aluminic Oxid	0.040	0.777	0.073	0.108
Manganic Oxid	0.210	0.216	0.575	0.194
Loss on Ignition	0.714	0.548	0.923	2.716
Sum	102.322	104.251	102.568	102.285
Oxygen equivalent to Chlorin	1.761	3.778	2.169	2.085
Total	100.561	100.473	100.399	100.200

COMPOSITION OF ASH COMPARED WITH SUGAR CONTENT.

	Vilmorin.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.	Kleinwanz-lebener.
Where grown............	Col. Farm	Col. Farm	Col. Farm, alkali soil	Col. Farm, alkali soil	Col. Farm, alkali soil	New Mex.
Sugar content...........	13.02 per ct.	12.32 per ct.	7.86 per ct	10.73 per ct.	14.70 per ct.	17.25 per ct.
Date harvested..........	October 13	October 13	Sept. 2	Sept. 22	October 13	?
Silica....................	1.58	1.54	2.10	1.02	1.33	1.91
Sulphuric Acid..........	3.59	4.47	3.91	4.37	4.18	3.53
Phosphoric Acid........	7.62	11.02	10.73	10.65	10.45	4.25
Chlorin.....	13.61	7.30	15.08	15.53	15.16	15.90
Potassic Oxid..........	50.12	41.41	48.74	50.42	51.70	50.59
Sodic Oxid..............	13.96	22.91	15.05	11.81	10.60	12.65
Calcic Oxid..............	4.26	4.19	1.46	2.64	2.35	4.42
Magnesic Oxid.........	6.59	7.76	5.02	6.68	6.70	8.93
Ferric Oxid.............	0.52	0.37	0.73	0.37	0.18	0.59
Aluminic Oxid..........	0.99	0.34	0.46	0.19	0.65	0.29
Manganic Oxid..........	0.23	0.39	0.16	0.26	0.13	0.45
Sum	103.07	101.70	103.44	103.54	103.40	103.54
Oxygen equiv. to Chlorin	3.05	1.65	3.40	3.50	3.42	3.59
Total	100.02	100.05	100.04	100.04	99.98	99.95

Composition of ashes of beets having different percentages of sugar, calculated from data quoted from Champion and Pellet by Dr. McMurtrie:

	Beets Having 10 per Cent. Sugar.	*Beets Having 15 per Cent. Sugar.*
Silica	5.555	5.546
Sulphuric Acid......................	3.594	3.486
Phosphoric Acid....................	9.640	9.357
Chlorin	9.310	9.172
Potassic Oxid........................	47.870	48.807
Sodic Oxid...........................	8.330	8.257
Calcic Oxid..........................	6.860	6.970
Magnesic Oxid	6.210	6.055
Undetermined.......................	2.610	2.385
	99.979	100.035

The leaves, presumably belonging to the two samples whose ash analyses are given above, yielded ashes of the following composition :

	Ash of Leaves from Beets Having 10 per Cent. Sugar.	*Ash of Leaves from Beets Having 15 per Cent. Sugar.*
Silica	1.100	1.110
Sulphuric Acid	5.340	5.400
Phosphoric Acid	7.940	8.000
Chlorin	11.510	11.560
Potassic Oxid	32.880	33.330
Sodic Oxid	11.510	11.560
Calcic Oxid	12.470	12.500
Magnesic Oxid	10.010	10.100
Undetermined	7.230	6.400
	99.990	99.960

The analyses, quoted from Champion and Pellet, evidently include, under the term undetermined, the excess of oxygen corresponding to the chlorin present. The large quantity of silica in the beet ash suggests the fluxing of sand and fine particles of soil during the incineration of the sample.

This source of silicic acid in the ash, has been frequently suggested in my own work, and I am fully convinced, that it is so good as impossible to prepare an ash from a sample containing sand and dust without fluxing some of it, and so bringing silicic acid into a soluble form. And I doubt the correctness of the practice of reckoning even the soluble silicic acid in the ash analysis proper.

Neither the analyses of the ashes from my own series, nor the two quoted, show a sufficiently decided variation in the composition of the ashes of beets, having different percentages of sugar, to admit of any conclusion in regard to any relation existing between the percentage of sugar and the composition of the ash. Further, a comparison of the percentages of sugar and ash present in mature beets, fails to show any relation between the percentage of sugar and the percentage of ash, as a few examples will serve to show:

RELATION BETWEEN PERCENTAGES OF SUGAR AND ASH.

	Per Cent. of Sugar.	*Per Cent. of Ash in Dry Matter.*	*Per Cent. of Ash in Fresh Beet.*
Beets harvested October 13	12.15	7.43	1.27
Beets harvested October 13	14.70	6.49	1.17
Beets harvested October 13	10.13	5.56	1.14
Beets harvested October 13	12.49	7.72	1.25
Beets harvested October 13	12.84	6.60	1.25
Beets harvested October 13	13.61	5.71	1.11
Beets harvested October 13	11.84	9.75	1.39
Beets harvested October 13	15.20	7.05	1.27
Beets harvested October 13	12.15	4.97	1.09
Beets harvested October 13	13.65	10.65	1.45

The only thing shown by these samples is that the ash of the sugar beet, as it grows with us, contains more alkalies than is shown by the two analyses of French beets, by about 7 per cent. The ash from our beets, without any relation to the sugar content, carries

about 63 per cent. of potash and soda together. The carbonic acid, sand, and organic matter, is not considered as belonging to the ash. We also find a certain uniformity in the amount of lime and magnesia present. Counting these in terms of lime, we find the range mostly within the limits of 11 and 14 per cent. In the two samples of French beets it is 15.5 per cent. The phosphoric acid in the eight analyses, which we have tabulated, agree closely in six instances, while the other two are much lower. In the case of the sample of Vilmorin, harvested October 13, and carrying 13.02 per cent. of sugar, the low percentage of phosphoric acid cannot, in my opinion, be explained by ascribing it to the lack of this constituent in the soil, it must be ascribed to some other cause. In regard to the sample from New Mexico, I can express no opinion, as I have no intimate knowledge of the conditions under which it was grown. I am frank to say that I doubt whether this New Mexican sample ought to be taken as an example of a beet, rich in sugar. That it showed the presence of 17.25 per cent. of sugar when I received it, is true, but that it did not show that much when it was fresh, is quite as certain. I believe the high percentage to have been due to drying out, rather than to a naturally high degree of richness.

The percentage of ash, in the French samples, is rather lower than we find in our samples, but other data for French beets make it about the same. The percentage of ash in the leaves, assuming the dry matter equal to 10 per cent., is the same as we find for Colorado beets, but the composition of the ashes of the leaves is not at all alike. They are similiar only in containing the same chemical elements. The composition of the ash of the leaves from the French beets is quite comparable to that of the ash of the beets themselves, the differences consisting of an excess in the percentages of soda, lime, magnesia, and chlorin, over that of the beet ash, while the percentage of potash in the ash of the leaves is less than that in the ash of the beets by 15 per cent.

The table on page 54 shows to how great an extent the ash constituents of the leaves differ from those of the beets in their relative quantities, and also, how the ashes, both of the roots and the leaves, of Colorado grown beets differ from those grown in France. I have quoted the analyses of the French beets, and do not know how nearly representative they may be, but as to the Colorado beets, any one of the samples given on previous pages could be used for the same purpose quite as well as the one chosen. This one was taken simply because its percentage of sugar, being so near that of the sample quoted, eliminates any question of doubt which might arise because of differences in the quality of the beets.

I place the analysis of a sample of the ash of Kleinwanzlebener beets, carrying 14.7 per cent. sugar, together with that of the ash of its leaves, side by side with that of a French beet, supposed to carry 15 per cent. sugar, and its leaves :

	Kleinwanzlebener. Grown in Colorado.		Grown in France.	
	Beets. Per Cent.	Leaves. Per Cent.	Beets. Per Cent.	Leaves. Per Cent.
Silica	1.330	0.890	5.546	1.110
Sulphuric Acid	4.180	4.470	3.486	5.400
Phosphoric Acid	10.450	2.120	9.357	8.000
Chlorin	15.160	32.670	9.172	11.560
Potassic Oxid	51.700	30.270	48.807	33.330
Sodic Oxid	10.600	26.270	8.257	11.560
Calcic Oxid	2.350	2.980	6.970	12.500
Magnesic Oxid	6.700	7.260	6.055	10.100
Ferric Oxid	0.180	0.150	2.385*	6.400*
Aluminic Oxid	0.650	0.150	....	....
Manganic Oxid	0.130	0.160	....	....
Sum	103.400	107.390	....	....
Oxygen equivalent to Chlorin	3.420	7.380	....	....
Total	99.980	100.010	100.035	99.960

* Undetermined.

In considering the effect of the soil, particularly of the alkali, upon the percentage of sugar, I adopted, as a standard of comparison, beets grown upon two other plots of ground, free from alkali, and in good tilth. In this case the meteorologic conditions were the same in every respect, and it was simply a question of soil. The same was true in regard to the feeding value, of both the roots and the leaves; with the constituents of the ash, which are obtained wholly from the soil, the question is not so simple, for there is an uncertainty in regard to the measure in which one constituent may replace another in the economy of the plant, and also in regard to the conditions which influence the replacement of one compound by another.

Some points are so evident, regarding the composition of the ashes from my plot, *i. e.*, that the sulphuric acid is very constant at about 3 per cent., and that the magnesia and lime are also nearly constant, that a multiplication of analyses had no object. In the series of samples, taken September 2, we have for the magnesia, in the samples taken from the three sections, 4.48 per cent., 4.10 per cent., and 4.47 per cent., and for the lime we have 1.74 per cent.,

1.19 per cent., and 1.22 per cent. The phosphoric acid is almost as constant, its limits being, as a rule, within 1 per cent., as the series taken October 13, in which we have 8.05 per cent., 8.67 per cent., and 7.50 per cent., may illustrate. It was then evident, that, so far as my own series was concerned, the variations in the composition of the ashes were to be looked for in the chlorin and the alkalies. We obtain a clear view, in regard to the amount of alkalies present, by comparing the alkalies in the different samples after we have eliminated the sand, the carbon dioxid, and the organic matter; when we find, for a series of six ashes, the following figures: 64.08 per cent., 64.32 per cent., 63.79 per cent., 62.23 per cent., 62.30 per cent., and 63.24 per cent. There is here a general rule, holding, at least for my samples, *i. e*, that the total alkalies amount to about 63 per cent of the ash. The percentages of chlorin in the series of six ashes from which the figures for the alkalies have been taken, present one exception; the percentages are as follows: 13.61 per cent., 7.30 per cent., 15.08 per cent., 15.53 per cent., 15.16 per cent., and 15.90 per cent. Owing to the one exception, I will give six others, in two series of three each, one series taken September 22, and the other October 13. Neither has been corrected for carbon dioxid, etc. The September series gave: 11.49 per cent., 12.82 per cent., and 14.41 per cent., the October series gave 14.96 per cent., 12.60 per cent., and 13.56 per cent.

We conclude that the ash of the beet, that is the root, has a pretty uniform composition, represented by the following percentages, the carbon dioxid, organic matter, and sand, included: For sulphuric acid, about 3.5 per cent.; for phosphoric acid, from 7 to 9 per cent., mostly about 8.5 per cent.; for the alkalies, from 48 to 52 per cent.; for lime, from 2 to 3 per cent.; for magnesia, about 6 per cent., and for chlorin, from 11.50 to 14.50 per cent., while the carbon dioxid does not vary by more than 1 per cent. from 15 per cent. of the fine ash.

It is easily recognized that either all of our soils had the same effect upon the ashes of the different samples, or the composition of the ash of the beet root is really constant, and is but little effected by the variety of soil. I believe the latter to be the case, *i. e.*, that the variation in the general composition of the ash of the beet root is constant within narrow limits, and is not materially affected, beyond those limits, by the character of the soil.

I, unfortunately, have almost no analyses of beet ashes at my disposal, and the few I have cannot be reduced to any common basis, and lose much of the value that they might otherwise have. The best I have is an average analysis taken from Wolff's "Aschen Analysen." According to this, the alkalies amount to 66 per cent. of the ash, carbon dioxid, etc., rejected, the lime and magnesia together to 11.5 per cent., phosphoric acid 11 per cent., sulphuric acid 4 per cent., but the chlorin is only 5 per cent.

The two analyses, quoted from Champion and Pellet, by McMurtrie, give 60 per cent. for the alkalies, 10 per cent. for the chlorin, 7.5 per cent. for lime, and 6.5 per cent. for magnesia. The Massachusetts Report, of 1894, gives for the alkalies, uncorrected, 53.3 per cent., for the phosphoric acid 9.7 per cent.

The experiment was undertaken to determine the effect of the excessive quantity of alkali salts upon the beet, and in the hope that we might find the condition of the land ameliorated by the removal of soda salts. The effect upon the percentage of ash in the beet was to raise it from 2 to 3 per cent., and this increase was proportional in the components of the ash, so that the proportion of alkalies remained the same. The ratio of the soda to the potash was not affected, as I had hoped to fine it; in fact, it was lower for the soda to the potash, in the ashes from samples grown on alkali ground, than in that from some samples from the Farm plots which I had taken as my standard. In samples from sections 1 and 2 of my plot the percentage of soda varied from 10 to 15 per cent. The average analysis taken from Wolff's tables is 10.25. The samples taken from section 3, varied from 16 to 19 per cent., with a corresponding depression of the percentage of potash. This increase in the soda ratio is general in the samples from this section, and I, at first, considered it as due to the influence of the alkali, but one of the samples from the Farm plot, where there is no alkali, in the sense in which this term is used, showed 18 per cent. of soda, and the beets were of excellent quality. I think that the causes which brought about the appropriation of the soda in the two cases were different; still so long as the causes are not definitely determined, the presence of 18 per cent. of soda in the latter case fairly raises a doubt whether the excessive soda salts, in the soil, was the real cause of the large percentage of soda in the former case, as I believe they were. The total alkalies taken up from the alkalized ground, was almost exactly the same as that taken up from the good ground.

The chlorin in the ashes, with one exception, is nearly the same, but the average is higher for my plot, owing to the influence of section 3. The conclusion is this, that on soil which is in good, or even fairly good, mechanical condition, the composition of the ash of the beet is not affected by the presence of alkali, but the percentage of ash is raised. On land, however, which is wet and in bad condition, the alkali increases the amount of soda and chlorin in the ash. This increase in the soda amounts to from 4 to 7 per cent., and in the percentage of chlorin to about the same. The conditions which are required to produce these results are so unfavorable, that the production of any other crop is quite out of the question.

The lime and magnesia, as already stated, are constant in their respective percentages, but they are much lower than the percentages for the German and French samples or averages. This cannot

be due to any deficiency of these compounds in the soil, for both the soil and the ground water are rich in them. I have neither an explanation nor a theory to offer. The twenty odd analyses agree in showing that, especially, the lime is low. The ground water carries from 125 to 200 grains of calcic sulphate ($CaSO_4$) to the gallon, and the soil is full of this salt. It is evident, from the very low lime percentage in the ash, that the beet does not appropriate it freely—indeed, scarcely at all. The same is suggested by the uniform percentage of sulphuric acid, not only in regard to the calcic sulphate, but also in regard to the sodic sulphate.

In regard to the leaves, I can find no more data than regarding the beets. All that I can find is from the sources already mentioned, Champion and Pellet, quoted as above, and an average analysis taken from Wolff's tables. These agree as well as one could expect, for the German analysis is an average, while the two French ones are of individual samples.

The French analyses make the sulphuric acid 5 per cent., phosphoric acid 8 per cent., chlorin 11.5 per cent., potash 33 per cent., soda 11.5 per cent., lime 12.5 per cent., and magnesia 10 per cent. The German data give the sulphuric acid as 5 per cent., the phosphoric acid as 7 per cent., potash 28.5 per cent., soda 14.5 per cent., lime 14.5 per cent., and magnesia 14.5 per cent. These percentages are only close approximations, but they are sufficient to convey a pretty definite idea of the composition of the ash of the leaves, as given by these authorities.

I have, in the tables, placed the analyses of nine samples of ashes from leaves, side by side, with those of the beets on which they grew, in order that the composition of the leaf-ash and beet-ash might be easily compared, but I have no analysis of a leaf-ash which may be taken as as standard, so there remains nothing else than to take the general averages given by Wolff's average analysis. A comparison of any of my analyses with this shows a wide departure from it. The sulphuric acid is some lower, the phosphoric acid very much lower—5.6 per cent.—the chlorin is over twice as high, the potassic oxid is from 3 to 5 per cent. lower, the sodic oxid 8 to 10 per cent. higher, the lime about 12 per cent. lower, and the magnesia 8 or 9 per cent. lower. In other words, there is no agreement at all, and I take my analyses, of October 13, as representing the composition of the ash of beet leaves, according to which we have, for sulphuric acid, 3.5–3.9 per cent.; for phosphoric acid, 1.8–2.3 per cent.; potash, 23.7–25.7 per cent.; soda, 22.3–25.5 per cent.; lime, 1.5–2.5 per cent.; magnesia, 6.0 per cent.; chlorin, 23.3–28.5 per cent.; carbon dioxid, 10.6–15.0 per cent. The soda may be too high, and the potash too low, by a few per cent., but the percentages serve to indicate the general composition of the ash.

The weight of leaves to the single plant is over 100 per cent. greater than that given for the average good beet in France. The few statements which I have found indicate a higher percentage of dry matter, 11 to 16.5 per cent., than I find for our leaves. It must be remembered that leaves, so succulent as the beet leaf is, lose weight very rapidly, and that the percentage of dry matter in the leaf, at the time of weighing, will depend upon the length of time that they have been pulled, and also, upon other circumstances. The percentage of ash, in the dry matter, is given as 28 to 30 per cent., in ours it ranges from 25 to 31 per cent.

In a preceding paragraph it has been pointed out that, while there is a general composition assignable for the ash of the beets, there is none, in the same sense, for that of the leaves, and I can only compare the samples from different sections of my own plot. In discussing the beet ashes I made no mention of any differences due to the different stages of development at the time the sample was taken. The reason for this apparent omission is, that there is no regular variation large enough, and constant enough, to force one to the conclusion that it is due to this cause. In illustration of this, we will take the beets from section 2 for the three dates, September 2, September 22, and October 13, when we have, for sulphuric acid, 3.19 per cent., 3.61 per cent., and 3.48 per cent.; for phosphoric acid, 8.76 per cent., 8.79 per cent., and 8.68 per cent.; for carbon dioxid, 14.82 per cent., 14.76 per cent., and 15.69 per cent.; for chlorin, 12.31 per cent., 12.83 per cent., and 12.60 per cent.; for potash, 38.83 per cent., 41.62 per cent., and 42.98 per cent.; for soda, 12.13 per cent., 9.74 per cent., and 8.81 per cent., and if the potash and soda be taken together, there is practically no difference in the percentage of alkalies present on the three dates.

The whole analyses might be given, but would show no exception to the statement that the ash in the immature beet had the same percentage composition as that in the mature beet. There seems to be one exception to this rule in the leaf-ashes, and this is in the case of the chlorin, which increases so generally and uniformly that it is suggestive of a relation between the maturity of the plant and the quantity of chlorin present. The percentages are averages for the dates September 2, September 22, and October 13, in the order given—18.98 per cent., 24.68 per cent., and 26.52 per cent. This is the only one of the constituents which shows this variation. The alkalies, on the other hand, are quite constant, with an average of about 48.4 per cent., against 52.0 per cent. in the beets. The alkalies in the leaf-ashes are, in a rough way, divided about equally, with the soda usually, but not always, slightly predominant. We conclude that the ash of the beet leaf has a general composition which is the same throughout the season, except that there is an accumulation of chlorin, as the plant approaches maturity.

The principal differences between the ash of the roots, and of the leaves, are the following: The ash of the roots contains from three to four times as much phosphoric acid; from one half to two thirds as much chlorin; about one thirteenth more alkalies; a little less lime, and two thirds as much magnesia. The most important of these differences is the smaller quantity of phosphoric acid in the ash of the leaves, the larger quantity of chlorin, and, not the difference in the quantity of the total alkalies, but in the ratio of the soda to the potash in them, which has been stated to be 1:1, roughly, with exceptions in favor of a higher soda ratio.

Apropos to the question of this ratio in the beet ashes, I notice a great variation in the analyses taken from Wolff's tables. The ratio for soda to potash is 1:2, and in tne analyses of Champion and Pellet, it is 1:6. In my samples the ratio varies from 1:1.8 to 1:5. The largest amount of soda was found in samples from section 3, and the next highest was found in a sample representing the Farm plot, supposed to be entirely free from alkali, and which is in most excellent condition. I have no analysis of the soil from the Farm plot, but as it was a piece of old alfalfa sod, there was probably an abundance of available potash present.

The principal effects of the alkali upon the beet crop were, in cases where the alkali alone was in question, that the percentage of sugar was scarcely affected at all, but rather beneficially than otherwise. That the nitrogen content was increased, and the ash content, also, by about 2 per cent.

THE FOOD REQUIREMENTS OF THE CROP.

I, of course, hoped to find this plant so tolerant of soda salts that it would utilize soda in its economy in place of potash, and thereby to be able to remove them from the soil, or at least to forestall their accumulation to a deleterious extent. As touching this particular object, the study leads to an adverse conclusion, or, at best, leaves it in serious doubt, for, with two exceptions, we do not find the amount of soda removed to be dependent upon the relative quantities of this compound in the soil. In the two cases in which larger amounts of soda than normal, or what appears to be normal, were removed, one could and the other could not be attributed to an alkalized condition of the soil. But we are enabled, by the establishing of a general composition for the ashes of the beets, and of the ratios between the roots and the tops, and the dry matter in each, to give the requirements of this crop in Colorado in quite definite terms. If we assume a crop of fourteen tons to the acre, and this will be a good average crop for our section, we have a total of from 294 to 384 pounds of mineral matter removed by the roots. This is on a basis of 1.05 per cent. ash in the fresh beets, grown on good soil, and 1.3 per cent. for beets grown on alkali soil. The tops will

remove about 586 pounds, assuming them to be equal to 80 per cent. of the weight of the roots, and to have an average of 2.62 per cent. of ash, which is their average on our soils. This gives us a total ranging from 880 to 970 pounds of mineral matter per acre—or deducting one seventh for carbon dioxid, we have from 754 to 832 pounds—of which nearly 60 per cent., or from 450 to 500 pounds, is potash and soda together. The ratio of the soda to the potash is so indefinite, as has been shown, that there is no basis for a very close estimate of the amount of soda removed, but, owing to the large large amount of ash in the leaves, and the richness of this ash in soda, about one half of the total alkalies, or from 225 to 250 pounds, must be soda. The total phosphoric acid removed is between 40 and 50 pounds. This is more than the average German crop of equal weight removes. The chlorin removed has possibly more significance for our main question than any other constituent. We may consider the ash of the root, including the carbon dioxid, as containing 12 per cent., and that of the leaves as containing 25 per cent. On this basis the roots remove from 35 to 46 pounds, and the leaves 146.5 pounds of chlorin per acre, which corresponds to about 307 pounds of sodic chlorid, or salt, to the acre. The sodic chlorid seems to be the only constituent of the alkali removed by the beet plant, but as the sulphate of soda constitutes the principal part of the alkali, and this being without influence upon the composition of the ash, it is not clear, even granting that we could raise a crop of 14 tons to the acre, to what extent the removal of this amount of sodic chlorid would better the condition of the soil.

The soil in question contains chlorin to the amount of 0.025 per cent. of the air-dried soil, or, taken to the depth of two feet, about 2,800 pounds of sodic chlorid to the acre. The water, soluble in the soil, varies in different portions of the plot from 0.09 per cent. to 1.4 per cent. of the air-dried soil. The salts, soluble in water, consist of sodic sulphate, 33 per cent.; calcic sulphate ($CaSO_4$) 36 per cent.; magnesic sulphate ($MgSO_4$) 21 per cent.; sodic chlorid 2.5 per cent.; and loss on ignition, rather less than 7 per cent. The quantity removed would soon reduce the supply of the sodic chlorid in the soil if it were not renewed from some source, but the ground water is charged with alkali, of which from 3 to 10 per cent. is sodic chlorid, a quantity quite sufficient to replace that removed by the crop.

A legitimate question here, is whether this amount of sodic chlorid, 2,800 pounds to the acre, taken to a depth of two feet, has any detrimental effect upon the growth or quality of the crop. I think that the answer must be that it does not.

While the experiment was made with sugar beets, I did not exclude stock beets, and an examination of the analyses of these races, given with those of the sugar beets, shows that they remove a much larger quantity of soda salts in the roots than the sugar beet does,

but this is confined to the roots, as the ratio of the weight of the leaves to that of the roots is only about one half as high in the stock beets as in the sugar beets; so that the actual weight of the leaves in the two cases is about the same. Still it appears from the analyses that the stock beets would remove more soda salts from the soil than the sugar beets, crop for crop, but not ton for ton. The percentages of dry matter and sugar show what the relative feeding value of the crops would be. It appears, considering all things, that the Lane's Imperial was the best variety for my purpose, and probably would be for feeding purposes, but this discussion lies beyond the scope and purpose of this bulletin.

SUMMARY.

The object of this bulletin is to present the results of my study of the effect of alkali upon the composition of the sugar beet, and to contribute to our knowledge of the chemistry of this plant.

The beet seed will germinate freely in soil containing as much as 0.10 per cent. of sodic carbonate, but the young plants are attacked by as much as 0.05 per cent., and it is doubtful whether any of them can survive when there is as much as 0.10 per cent. of this salt present in the soil.

Sodic sulphate affects the germination to a much less degree, even when it is equal to 0.80 per cent. of the air-dried soil, but it is injurious when present in larger quantities. When both salts, sodic carbonate and sodic sulphate, are present in equal quantities, the action of the carbonate, or black alkali, is only slightly, or not at all, mitigated.

Magnesic sulphate retards, but does not prevent, germination when present in quantities equal to 1 per cent. of the air-dried soil.

Sodic salts hasten germination by from 36 to 48 hours.

The effect of the alkali, present in our soil, upon the sugar content of the beet is, of itself, not detrimental. The maturing, or ripening, of the crop corresponds to an increase of from 2 to 3.5 per cent. of sugar in the beet, and about one third of the total yield of sugar.

Beets may remain unharvested, under favorable conditions, without loss of sugar or weight of crop. In our case, there was a slight gain between October 6, 1897, and January 8, 1898.

The difference in the average percentage of sugar in the thirds of beets, taken by weight and numbering from the top, is less than 0.20 per cent. in favor of the second and third thirds, while average co-efficient of purity is quite the same for the respective thirds.

The percentage of sugar in the crowns is about 1 per cent. less than in the rest of the beet, and the co-efficient of purity is but little lower than that of the beet.

Simple freezing does not affect the quality of the beet. The sugar is not changed thereby, but the distribution of the sugar in the beet may be materially affected in cases where only a portion of the beet has been frozen, especially if subsequent thawing has taken place.

The drying out of beets increases the percentage of sugar, but is accompanied by an actual loss of sugar.

The rate of drying out is about 5 per cent. for the first 24 hours, but by the end of five days it falls to about 2 per cent., and remains practically constant for the next 12 days.

The weight of the leaves of the Colorado grown sugar beet, equals about 87 per cent. of the weight of the roots. The weight of the leaves does not increase materially during the last six weeks of the growing season, but during this time the weight of the root increases by 64 per cent. of its weight at the beginning of the period, or 39 per cent. of the weight of the mature beet.

The presence of alkali increases the weight of the leaves very slightly, and has no marked influence on the date of maturing.

The amount of dry matter is the same in beets grown upon alkali ground as in those grown on ground free from alkali.

As the sugar is formed, there is a disappearance of dry matter, other than sugar, in the beet, suggesting the formation of the sugar in the root by the transformation of substances already deposited therein.

The dry matter in the upper, or first, third of the beet, taken by weight, is a little higher than in the other two thirds.

The effect of the alkali upon the composition of the beet, as shown by the ordinary fodder analyses, is an increase in the percentages of the ash, and the crude protein, and a decrease in the percentage of nitrogen free extract. The effects of the alkali are greater upon the composition of the beet than upon that of the leaves.

The percentage of ash in the fresh roots is about 1.10 per cent., and in the fresh leaves it is rather more than twice as much.

The effect of alkali upon the percentage of ash in the roots is to increase it by about 2 per cent., reckoned on the dry matter.

The amount of mineral matter removed by a crop of stock beets is from two to three times as great as that removed by a crop of sugar beets. The amount of mineral matter removed by the leaves is about the same.

The percentage of ash in the respective thirds of the beet, taken by weight, is, for the fresh beet, a little higher in the upper third

than in either of the other two thirds, but the dry matter from the third, or bottom, third is richer in ash than either of the other two thirds.

I have failed to find any relation between the percentage of sugar and the percentage of ash, and also between the percentage of sugar and the composition of the ash.

The composition of the ash of the beets seems not to have been affected by the different character of the soils experimented with, either because there was so great an abundance of available, and to the plant, acceptable mineral matter present that it was not affected by the presence of a large quantity of other salts, or the composition of the ash of the sugar beet is very constant. I think that the latter is the case; the composition of the ash being represented by the following approximate percentages: Sulphuric acid, 3.5; phosphoric acid, 7–9; alkalies, 48–52; lime, 2–3; magnesia, 6; chlorin, 11.50–14.50; carbon dioxid, about 15.

The ash of the beet leaf has a general composition which, like that of the beet, is the same throughout the season, except that there is an increase in the chlorin as the plant approaches maturity.

The ash of the leaves differs from the ash of the roots in the following points: The ash of the leaves contains from one third to one fourth as much phosphoric acid, from two to three times as much chlorin, a little more lime, about one half more magnesia, and about one thirteenth less alkalies. The most important difference is the ratio of the soda to the potash, which is one, or more than one, to one.

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The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 47.

Colorado's Worst Insect Pests And Their Remedies.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JULY, 1898.

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Colorado's Worst Insect Pests And Their Remedies.

BY CLARENCE P. GILLETTE.

INTRODUCTION.

It has been the object of the writer, in the preparation of the present bulletin, to put together, in condensed form, the largest possible amount of information that will be of practical value to the people of the state in combating insect pests. I have, therefore, avoided all technical expressions that might be annoying and meaningless to the general reader, and have only given the information that seemed to me necessary to enable one, who is not specially trained in entomology, to recognize the insect or its injury in each case and to know how to prepare and use the best remedies. There are a number of cases where the popular reader would say "worm," where I have said "larva," or "caterpillar," which are the more correct words; and I have used the words "pupa" or "chrysalis" for the resting stage of insects, but I take it that nearly all my readers know the meaning of these terms.

I have not attempted to make the present paper exhaustive, as that would be impossible in a bulletin of moderate size. I have only taken up those insects about which I am most often asked questions and concerning which I think information is most needed by the people.

It is hoped that all who are troubled with insect pests of any sort will feel free to make inquiries of the Experiment Station as to best methods of destroying them or preventing their injuries. Whenever possible, specimens of the insects or their work should accompany the inquiry.

ACKNOWLEDGEMENTS.

The figures that are not original in this bulletin, or that have not been used in previous bulletins of this station, have been obtained through the courtesies of Dr. L. O. Howard, Dr. J. B. Smith and Dr. C. M. Weed.

Figures 1, 4, 13, 14, 21, 30, 37, 41, 43 and 48 are duplicate electrotypes from Smith's "Economic Entomology" and were purchased from J. B. Lippincott & Co.

Figures 17A, 23 and 24 are duplicate electrotypes from "Insects and Insecticides"—Weed, and were purchased from Dr. Weed.

Credit for the other figures is given in each case, beneath the illustration.

APPLE-TREE ENEMIES.

THE CODLING MOTH. (*Carpocapsa pomonella* Linn.)

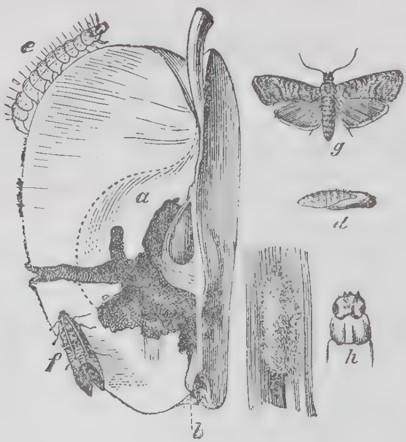

Fig. 1.—The Codling Moth: a, apple showing burrow; b, place where the worm entered; d, chrysalis or pupa; e, larva or worm; f, moth with wings closed; g, moth with wings spread; h, head end of larva; i, cocoon in which the larva changes to a chrysalis. All about life size except h. (After Riley).

A flesh-colored worm, eating into the fruit and making what are commonly called wormy apples. Common wherever apples have been grown for a series of years.

Remedies—About one week after the blossoms have fallen, make a thorough application of Paris green or London purple in a coarse spray in the proportion of 1 pound to 160 gallons of water. At the end of one week repeat the treatment, using the poison a little weaker (one pound to 200 gallons of water), unless heavy rains have intervened to

wash off the poison of the first application. The Kedzie arsenite of lime may be used in place of the above poisons if preferred.

In addition to one of the above mixtures use the following: Put burlap bandages on the trunks about June 15th and remove them every seven days to kill the larvæ and pupæ under them until the last of August. Then leave them until winter or *early* the next spring, when they should be again removed and the worms beneath them killed. The prompt destruction of fallen fruit will destroy some of the worms, but not a large proportion of them, probably about 15 per cent. Keep screens on windows and doors of cellars and fruit houses where apples are stored to prevent the moths that hatch in these places from flying to the orchard.

Scald in boiling water all boxes and barrels that have recently contained apples, pears or quinces.

THE APPLE FLEA-BEETLE. (*Haltica ignita* Ill.)

A small metallic-green beetle, about one-eighth of an inch in length, that eats holes in the leaves and jumps or takes wing quickly when disturbed.

Remedies.—Use London purple or Paris green in the proportion of one pound to 160 gallons of water; or use these poisons dry, diluted with flour. The Kedzie arsenite of lime, or arsenate of lead, would probably be equally efficient.

Dusting the foliage with lime, plaster, ashes, or tobacco dust, will usually drive the beetles from the trees, but these applications will not kill.

FRUIT-TREE LEAF-ROLLER (*Cacœcia argyrospila* Walk.)

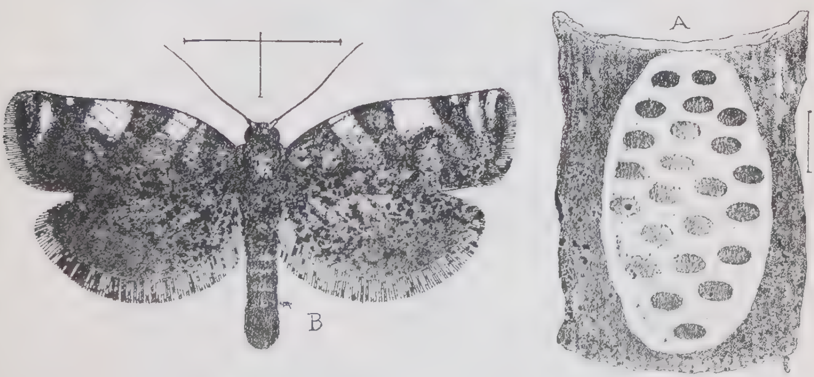

Fig. 2.—Fruit tree Leaf-roller: A, egg-patch on bark from which the worms have escaped; B, moth. Both enlarged. The lines at the sides show the actual sizes.

Light green worms with black heads appearing upon the trees as soon as the leaves begin to open. The leaves are rolled or folded about the worms for the protection of the latter from their enemies. When abundant, both apples and foliage are sometimes entirely destroyed. The worms change to pupæ in the leaf rolls from which small yellow or rust colored moths appear in July. These moths deposit their eggs in oval patches on the trunk and branches of the trees where they remain dormant until the following spring.

Fig. 3.—Fruit-tree Leaf roller: A, twig from apple-tree showing the rolled and eaten leaves; b, apples that have been eaten by the worms.

Remedies.—Crush as many of the egg patches as can be found during the winter or early spring when other work is not pressing. As soon as the blossoms have fallen spray with Paris green, London purple or arsenite of lime as for the Codling Moth. At the end of a week repeat the application. If heavy rains intervene, or if, for any reason, the worms are found to be continuing their work in large numbers after the end of another week, make a third application. Make the first treatment in the strength of about 1 pound of the poison to 160 gallons of water and the later ones a little weaker, about 1 pound to 200 or 240 gallons of water.

If the eggs are very abundant, it will be well to make one treatment just before the blossoms open.

The treatments made after the blossoms have fallen will also do service in destroying the Codling Moth and any leaf-devouring insects that may be present.

A thorough coating of white-wash upon the trunks and main limbs will destroy a large proportion of the worms while eating out from the eggs. My experiments have shown that the little worms cannot survive eating through a layer of lime over their egg patches. If the coating of lime does not cover the patches, or if it becomes loose and scales off before the worms eat their way out of the eggs, this treatment will do no good. The application of lime should be made about the middle of April, or just in advance of the blossoming of the earliest plum trees. Use the best quality of lump lime in making the wash.

Mr. David Brothers, of the Colorado State Board of Horticulture, reports great success in capturing the moths in pans of dilute cider vinegar set about the orchard at night. The moths begin to fly about the last days of June and continue for two or three weeks. This insect also occurs abundantly on many other trees, particularly, in this state, upon plum, cherry, pear, osage orange and currant and rose bushes.

THE TENT CATERPILLAR. (*Clisiocampa fragilis* Stretch.)

This insect is readily recognized by its white silken webs or tents in the crotches of the limbs of the trees early in the season. The tents begin to be formed as soon or a little before the leaves of apple trees begin to open. The caterpillars make their homes in the tents, but go out over the tree to feed. The tents are quite dense and seldom attain more than one foot in length. The caterpillars are all gone by the first of July.

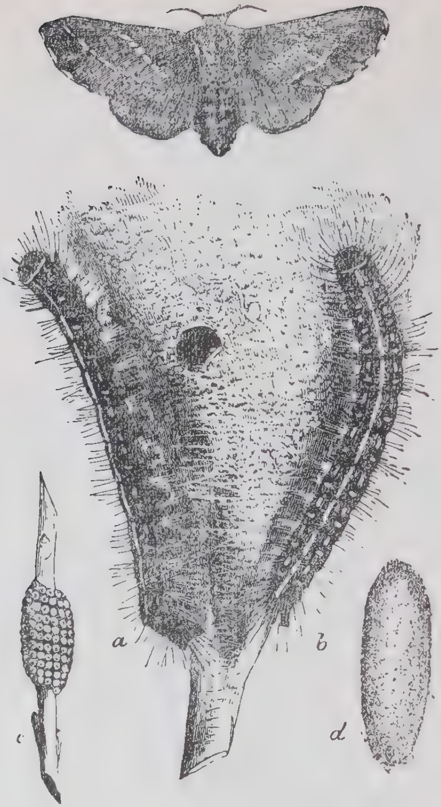

Fig. 4.—American Tent Caterpillar, (*Clisiocampa americana*): a and b, full grown worms on the outside of the tent; c, egg-mass with the gummy covering removed; d, cocoon containing the chrysalis; above all, the moth. (After Riley.)

Our western species (*Clisiocampa fragilis*) resembles the above so closely that the figure serves equally well for it.

Remedies.—Collect and burn the tents as soon as they are seen. This should be done early in the morning or in the evening when the worms are in the nests.

THE FALL WEB-WORM. (*Hyphantria cunea* Dru.)

A yellowish or brownish caterpillar with a black head that forms a large loose web or tent in a great variety of trees, beginning to appear about the first of July and continuing through the summer. The larvæ are rather sparsely covered with long hairs that are whitish or yellowish in color, with occasional black ones for variety. This insect is readily distinguished from the Tent Caterpillar in habits as the

larvæ of the Fall Web-Worm form a very loose tent with which they inclose the leaves upon which they feed, and they do not appear until the Tent Caterpillars have nearly or quite disappeared.

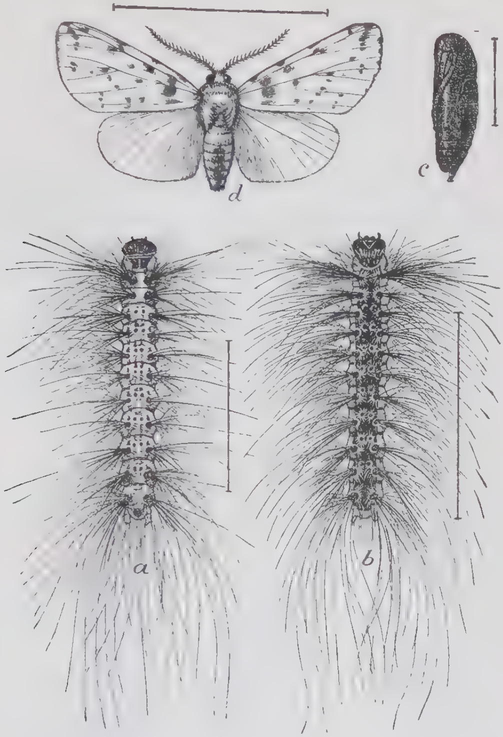

Fig. 5.—Fall Webworm: a and b, full grown larvae showing light and dark forms; c, the chrysalis; d, moth, showing dark spots. All some enlarged. The lines show the actual lengths. Usually the moths are entirely white. (Howard Yearbook, U. S. Dep. of Agr. 1895.)

Remedies.—If the webs are noticed when small they should be cut out and the larvæ destroyed. If the web has become large, enclosing many branches of the tree, it may be better to burn out the worms with a torch. Where there is no danger of poisoning fruit, Paris green may be sprayed or dusted upon the foliage immediately surrounding the web. These leaves will soon be enclosed for food and the worms eating them will die.

THE FLAT-HEADED APPLE-TREE BORER. (*Chrysobothris femorata* Fabr.)

A yellowish white larva boring beneath the bark in the

sapwood of apple and many other trees and quite peculiar in appearance on account of its having the anterior segments of its body (not its head) greatly enlarged and flattened.

Remedies.—This borer is usually found on the south or southwest side of the tree where the bark has been scalded by the sun and it seldom attacks healthy, vigorous trees. So that the protection of the trunk from sun-scald and other injuries to the bark will do much to prevent the attacks of this insect.

If the borers get into the trees their presence is detected by the dark color of the bark, and in such cases there is probably no better remedy than to make a vigorous use of the pocket knife for their removal. This may be done in the fall or winter when work is least pressing.

The use of strong soapy mixtures and of kerosene emulsion during the month of June and the fore part of July are also much recommended, but the writer believes the pocket-knife remedy will prove most satisfactory.

THE APPLE-TWIG BORER. (*Amphicerus bicaudatus* Say.)

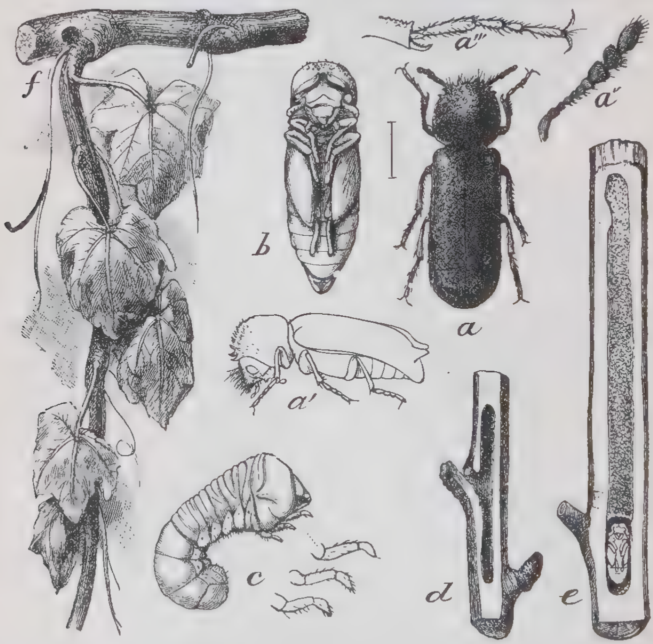

Fig. 6.—Apple Twig Borer: a, beetle, dorsal view; a', beetle, side view; b, pupa from beneath; c, grub, side view; d, apple twig showing burrow; e, burrow in tamarisk with pupa at bottom; f, stem of grape showing burrow. All enlarged except the stems showing burrows. (Marlatt, Farmer's Bull, 70, Div. Entomology, U. S. Dep. of Agr.)

A cylindrical, mahogany-colored beetle, about one-third of an inch in length, boring holes in twigs of apple, pear, cherry, osage orange and other trees and grapevines, the burrow starting just above a bud and extending downwards.

Remedy—Cut out the infested stems and burn them.

THE BUFFALO TREE-HOPPER. (*Ceresa bubalus* Fabr.)

A light-green, three-cornered insect, about one-third of an inch in length. What appears to be the head, really the thorax, is large and broad and terminates abruptly, having on either side a short, sharp spine, or thorn, somewhat resembling the horn of the buffalo, and hence the common name of the insect, which is, withal, a good jumper. This insect feeds upon a great variety of plants and is quite abundant in Colorado. It does its chief injury while depositing eggs during the months of August and September in small limbs of various trees, including the apple. A double row of eggs is deposited in a longitudinal slit that the female makes in the bark. The growth of the limb spreads the slit into an oval scar as shown in the accompanying illustration.

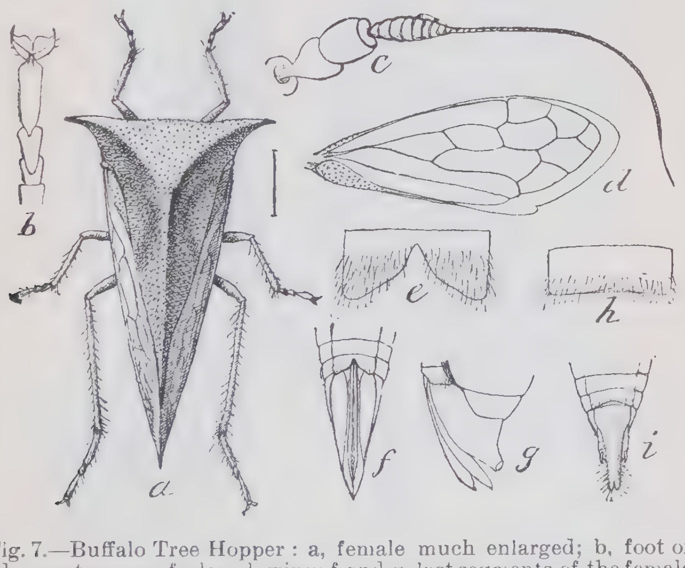

Fig. 7.—Buffalo Tree Hopper: a, female much enlarged; b, foot of same enlarged; c, antenna or feeler; d, wing; f and g, last segments of the female abdomen; i, last ventral segments of the male. (Marlatt, Circular 23, U. S. Dep. of Agr., Div. of Entomology.)

Remedy—These hoppers seem to have the habit of ac-

cumulating on certain small trees to deposit their eggs, so that some trees will be almost covered with scars, while others near by have few of them. About the only remedy seems to be to cut out the limbs in which the eggs have been deposited before the eggs hatch in the spring and burn them.

I have noticed these badly infested trees, as a rule, about the borders of the orchard or in orchards where a large amount of foul stuff was growing, and I believe clean culture will do much to keep this pest out of the orchards.

THE SCURVY BARK LOUSE. (*Chionaspis furfurus* Fitch.)

The presence of this insect is indicated by very small white scales upon the trunks or limbs of the trees, when abundant, entirely covering the bark and appearing like a covering of scurf or dandruff, and hence the common name. The female scales are broad and oval at one end and are about a tenth of an inch long; the male scales are not over one-twenty-fifth of an inch in length and are long and narrow.

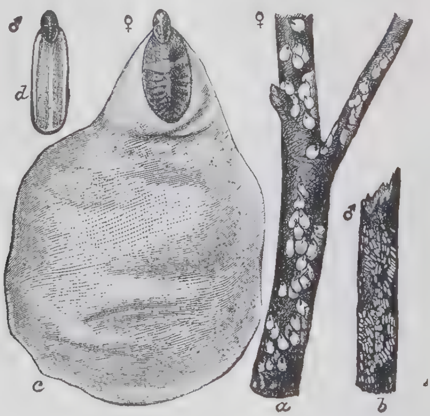

Fig. 8.—Scurvy Bark Louse: a, twig showing scales of female louse; b, twig showing scales of male louse; c, scale of female greatly enlarged; d, scale of male greatly enlarged. (Howard, Yearbook, U. S. Dep. of Agr., 1894.)

Remedies—Whale-oil soap, 2 pounds to a gallon of water, kerosene emulsion that is one-fourth kerosene, or lime, sulphur and salt mixture, applied while the trees are dormant, would probably kill the scales. After the leaves are out, if the lice have not been killed, use kerosene emulsion of ordinary strength about the last of May and again about the 10th of June.

THE OYSTER-SHELL BARK-LOUSE. (*Mytilaspis pomorum Bousche.*)

This scale is common in the eastern and northeastern U. S. and in Canada. It is an enemy of the apple-tree of considerable importance and will doubtless be found in some of the orchards of this State at no distant date, though it has not yet been reported in Colorado. It is a very easy pest to overlook. The scales are about one-eighth of an inch in length, a little curved like an oyster shell, and the color is almost exactly that of the bark of an apple tree. They occur chiefly upon the bark and, when abundant, weaken the vigor of the tree or even cause it to die. The scales are very well shown in Fig. 9. During the fall, winter and early spring, these scales have eggs beneath them. About the last of May the eggs hatch and the minute yellowish lice travel about over the tree, find suitable locations, insert their beaks, feed and grow, forming over themselves the peculiar scale under which they deposit eggs and die by the last of August or early in September.

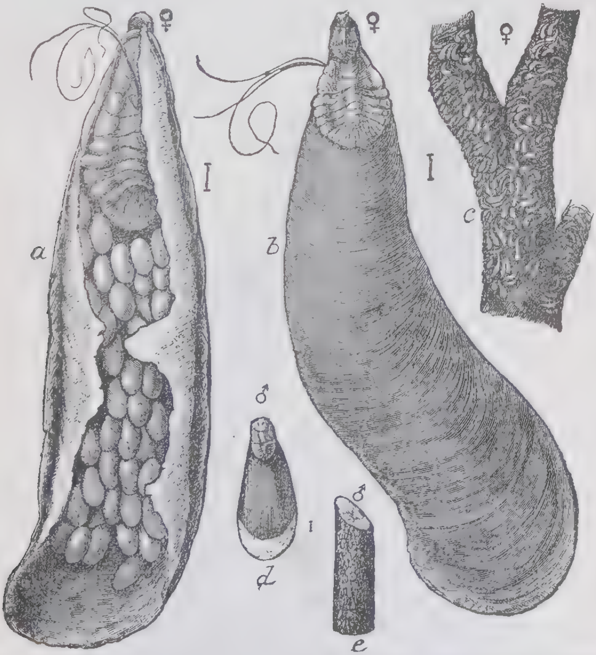

Fig. 9.—Oyster-shell Bark-Louse: a, female scale from below, showing eggs, greatly enlarged; b, the same from above; c, female scales on twig natural size; e, male scales, natural size; d, male scale enlarged. (Howard, Yearbook, U. S. Dep. of Agr., 1894.)

Remedies—The same as for the preceding species.

THE SAN JOSE SCALE. (*Aspidiotus pernicious* Comstock.)

This is the most dreaded of the insect pests of the apple orchard. As yet there has been no authentic record of its occurence in any of the orchards of this State, but it has been a most destructive orchard pest in California, Oregon, Washington, and in several of the eastern and southern states. It is transported from place to place almost entirely upon nursery stock and the utmost care should be exercised to prevent its gaining an entrance into any of the orchards of Colorado. It will feed upon almost any of the deciduous trees and shrubs and consequently is very hard to exterminate in any locality where it has once gained an entrance.

The scales are very inconspicuous so that trees are liable to be killed by the insects before the owner becomes aware of the presence of the scale.

The female scales are circular in shape and dark gray in color with a small red or rust-colored spot at the center and measure from one-sixteenth to one-twelfth of an inch across. The male scales are black in color and are smaller than those of the female. They occur upon trunk, limbs, leaves or fruit, and usually cause a reddish coloration of the tissue immediately about the scales, which is very characteristic of this species.

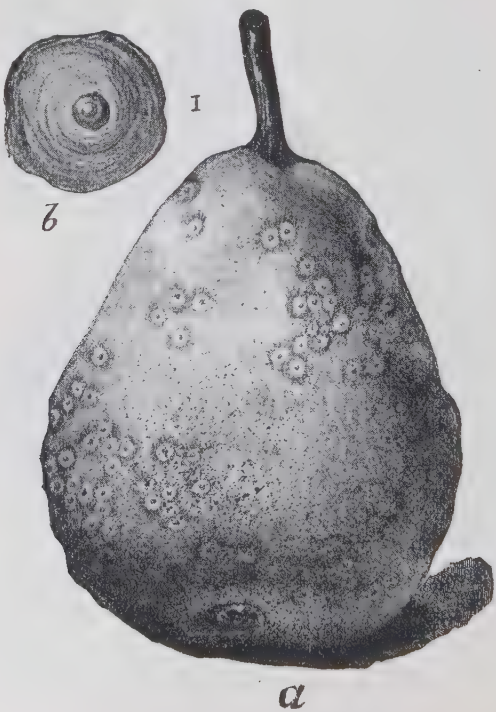

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Fig. 10.—San Jose Scale: a, pear showing the scales, natural size; b, female scale enlarged; B, section of limb showing scales natural size. (Howard, Yearbook, U. S. Dep. of Agr., 1894.)

Remedies—While the trees are dormant use the same remedies as are recommended for the Scurvy Bark-Louse. In case it becomes necessary to treat the lice after the leaves are out, use kerosene emulsion or whale-oil soap of the ordinary strengths and make five or six applications at intervals of about five days. If an orchard, or even isolated trees, become badly infested and the lice do not succumb to winter treatment, it will usually be better to cut down the trees and burn them completely.

PUTNAM'S SCALE. (*Aspidiotus ancylus* Putnam.)

This scale resembles the preceding so closely that it is impossible to give characters that will enable one who does not possess a compound microscope to distinguish between them with much certainty. The small male scales of this species are not black, however, as in case of the San Jose scale. When either of these scales are suspected it will be well to send specimens to the experiment station for determination.

Remedies for this species are the same as for the Scurvy Bark-Louse mentioned above.

THE APPLE PLANT-LOUSE. (*Aphis mali* Fabr.)

During the winter and early spring there are small shining black specks in rough places in the bark and about the buds, or, as is often the case when abundant, distributed promiscuously over the surface of small limbs, usually most abundant where there is abundance of fine plant hairs making a felty covering to which the eggs are easily attached. See Fig. 12.

Just before the buds open, the eggs hatch, producing a green louse which grows to about one-twelfth of an inch in length and which takes up its abode upon the leaves where it grows rapidly and, by its injuries, causes the leaves to curl so as to form for itself a partial protection.

Remedies—The best time for treatment is while the trees are dormant, any time after the leaves fall and before the buds open. For treatment during this time use either kerosene emulsion, double strength (diluting only enough to make the mixture one-seventh kerosene), or whale-oil soap in the proportion of 1 pound to six gallons of water. The very best time to make the application is after the lice have all hatched and just before the buds open enough to give the lice protection. The danger in waiting for this time is that one is liable to wait a day or two too long and then the lice will get into the open buds and be so protected that some will escape to perpetuate the species and the increase is very rapid.

After the leaves are out, kerosene emulsion of the ordinary strength (one-fifteenth kerosene), or whale-oil soap in the proportion of 1 pound to 8 gallons of water, are the best remedies. Apply as a spray and be sure to make the application thorough.

THE WOOLLY APHIS. (*Schizoneura lanigera* Hausm.)

A very soft-bodied louse, more or less covered with a white, flocculent excretion, resembling wool, and causing a blood-brown stain when crushed in the hand. One form of this insect occurs on the roots of the trees and produces wart-like swellings; another appears on the trunk and limbs and is usually densely covered with the woolly excretion.

Fig. 13.—Woolly Aphis, root form : a, small root showing swellings caused by the lice; b, wingless louse showing woolly secretion; c, winged louse. The lice are very much enlarged, the actual sizes being shown by the lines at the sides of the illustrations.

Fig. 14.—Woolly Aphis, aerial form, showing winged and wingless lice enlarged, and a scar on a limb that has been attacked by the lice.

Remedies—Probably the best remedy for the root form is tobacco dust worked into the ground to the amount of 3 to 6 pounds about the crown of the tree and then wet with water.

In the hands of one who has had experience, carbon bisulphide may be used effectually by injecting it into the ground about the crown of the tree. Kerosene emulsion, whale-oil soap and hot water, have all been used successfully, but probably all should give way to tobacco dust, which is cheap, effectual and lasting in its effects.

To keep the aerial form in check, begin in the latter part of May when the little white patches of lice begin to appear about wounds and tender places on the bark of the tree and, by means of a paint brush, apply pure kerosene to every patch of lice that can be found.

If the lice spread over the tops of the trees they may be treated with kerosene emulsion, ordinary strength, but it is necessary to throw it with a great deal of force so as to wet through the "wool" which protects the lice from any light spray.

Where the lice are found on the roots of nursery stock, it is advisable to dip the roots in ordinary kerosene emulsion, or in whale-oil soap in the proportion of 1 pound to 8 gallons of water or to fumigate with hydrocyanic acid gas.

Other insects mentioned in this paper that sometimes occur on the apple, are Red Spider, the Brown Mite and Grasshoppers.

Fig. 11.—San Jose Scale: a, female removed from scale; a, antenna; c, gravid female showing unborn young; d, tail end of a female, all greatly enlarged. (See page 14.)

PEAR-TREE ENEMIES.

THE BROWN MITE. (*Bryobia Pratensis*, Garman.)

This insect is also called "Clover Mite," and in some localities it is called "Red Spider" on account of the rust-red color, but the last name is applied to another mite treated on another page. The eggs of this insect are nearly globular, of a bright red color, and often occur in enormous numbers on the bark of pear, apple and other orchard trees, most often on the pear in Colorado. They give the bark a rusty red appearance and will stain the hand if it is rubbed over them. The eggs are so small that, without a glass, it would be impossible to discover their real nature. During May they hatch and the little mites coming form them are,

at first, a bright vermilion red in color. As they grow this color fades into a rusty brown. When mature, the mite resembles a very small spider and is just large enough to be plainly seen by one who has fairly good eye-sight.

As the result of the attacks of this mite the foliage of the tree becomes bleached and sickly in appearance. Aside from the pear it attacks badly the cherry, apple and plum and perhaps a few other trees.

Remedies—Those who use the lime, sulphur and salt wash in the vicinity of Grand Junction, Colo., assure me that it completely rids their trees of Brown Mite.

In my own experiments I have found whale-oil soap in the proportion of one pound to 4 gallons of water, or kerosene emulsion diluted so that the kerosene will be one-eighth of the mixture, applied before the eggs hatch, to destroy the latter completely, none whatever hatching where thousands were treated. The same applications in one-half the foregoing strengths will kill the mites after they hatch. The best time to make the treatment is before the eggs hatch.

THE PEAR-TREE SLUG. (*Eriocampa cerasi* Peck.)

This insect attracts attention as slimy, olive-green slugs upon the leaves, which they kill by eating off the soft part and leaving the veins. When abundant, they entirely destroy the foliage, leaving the leaves brown and dry as if killed by fire. There are two broods, one appearing in June and one in August.

Fig. 15.—Pear Slug: a, adult female fly; b, larva or slug with the slimy covering removed; c, same as the preceding in natural condition; d, leaves showing slugs and their injuries. (Marlatt, Circular 26, Second Series, U. S. Dep. of Agr., Div. of Entomology.)

Remedies -There are several remedies that may be successfully used against this insect. White hellebore lightly dusted over the foliage in the evening, or applied in a watery spray in the proportion of an ounce to three gallons, is probably the best. Paris green or London purple dusted or sprayed upon the foliage will accomplish the same result. Air-slaked lime or strong wood ashes have often been recommended and are probably of some use. Even fine road dust has been recommended as all sufficient for the destruction of the slimy larvæ of this saw-fly, but I am inclined to think that the last of these remedies, at least, is of little use, and I have dusted lime freely upon the slugs without any apparent harm to them. Pyrethrum, or Persian Insect Powder, dusted over the slugs will kill all that it comes in contact with.

This slug also attacks the foliage of plum and cherry trees.

THE PEAR LEAF-BLISTER. (*Phytoptus pyri* Scheuten.)

This disease is indicated by small black spots appearing upon pear leaves, sometimes so numerous as to run together and involve a great portion of the leaf. Before turning black the spots are green like the rest of the leaf. An examination of the spots will show that they are slightly thickened portions and each one is the habitation of a large number of very minute parasites.

Remedies—The parasites spend the winter, chiefly, under bud-scales upon the trees, and may be killed during winter or early spring, when the trees are dormant, by a spray of kerosene emulsion in which the kerosene is one-fifth of the mixture.

Other insects mentioned in this paper that are sometimes found attacking the pear, are: Codling Moth, Red Spider, Brown Mite, Fruit-tree Leaf-roller, Tent Caterpillar, Flat-headed Borer, Fall Webworm, Buffalo Tree-Hopper, San Jose Scale and Putnam's Scale.

PLUM-TREE ENEMIES.

THE PLUM GOUGER. (*Coccotorus prunicida* Walsh.)

This insect is often mistaken for the Plum Curculio, mentioned below, which does not occur in Colorado as yet. The Gouger is a native of the Western United States, where it has fed from time immemorial upon native plums and it

has not yet acquired a taste for th . more luscious European varieties. At least, it seldoms attacks anything but native varieties of the plum.

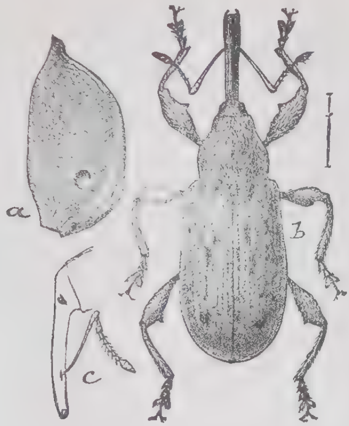


Fig. 16.—Plum Gouger: a, plum pit showing hole for exit of Gouger; b, Gouger. (Riley & Howard, Insect Life, Vol. II, U. S. Dep. of Agr., Div. of Entomology.)

The beetle is about one-fourth inch in length, has a rather long, curved snout, or rostrum; the wing covers are of a leaden gray color, finely spotted with black and brown, while the thorax and head are ocherous yellow. The beetles begin appearing before the blossoms open. At first they puncture the calyx and feed on the ovary of the flower, completely destroying it for the production of fruit. Later their punctures may be seen on the growing plums, some being made for food and others for the purpose of depositing eggs. In the laboratory six of the beetles, in 24 hours, punctured the calyces and ate the ovaries of 65 buds and blossoms. The punctures made for egg-laying are shallow and the egg, after being deposited, is flush with the surface

Fig. 17.—Plum Gouger and its punctures on a plum. (After Bruner.)

of the plum. For a short time it is yellowish white in color, but, where it is exposed to the light, it soon becomes shining jet black. The larvæ on hatching eat their way directly to

the pit leaving a minute black line to mark their course. On reaching the pit they do not burrow about it as in the case of the Plum Curculio but burrow straight on into the meat of the pit on which they feed until fully grown. Then the grub eats a hole through the pit so it can escape after it has changed to a beetle. The beetles emerge usually a little before the plums ripen, and destroy the fruit. The fruit that is punctured by the beetles becomes hard and gnarly and is usually worthless.

Remedies · My experiments do not indicate that poisonous sprays can be used to any profit against this insect. The best remedy we know of at present is to jar the trees daily, either in the morning or in the evening and catch the beetles on sheets spread beneath the trees. Make a large sheet for the purpose, slit it from the middle of one side to the center and, in using, pass the strips thus made either side of the tree so that the latter will stand at the center of the sheet. Two men can use such a sheet very rapidly. Begin the work as soon as the trees blossom and continue as long as you can get half as many gougers as the number of trees jarred.

THE PLUM CURCULIO (*Conotrachelus nenuphar* Herbst.)

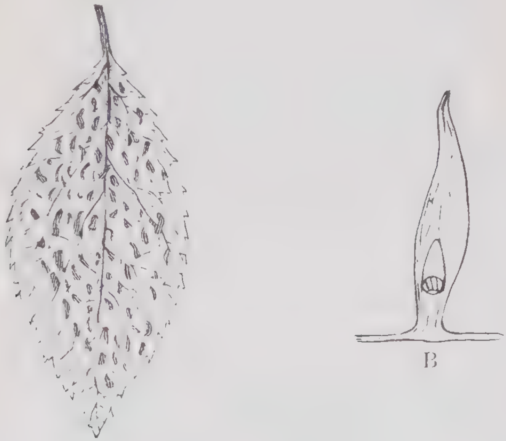
This is by far the most serious pest to plum culture in the East. It also attacks other pit fruits, including the cherry. A dark brown to blackish snout beetle, about one-fifth of an inch long and with four prominent humps on each wing cover. The mark that the beetle makes on the fruit when "stinging" it for the deposition of an egg is very characteristic and has given this insect the appellation, "Little Turk." A puncture is made with the jaws and an egg deposited in it and then the beetle turns about and cuts a crescent partly surrounding the egg. The grub eats through the flesh of the plum to the pit and then feeds about the pit but never eats into it. The fruit, as the result of this injury, falls.

Remedies—Jarring as for the Plum Gouger is the best remedy for this insect. Some benefit can be derived from the use of arsenical sprays but, if the same expense is put into the work of jarring and collecting the beetles, it is generally believed that more good will be derived.

Where chickens can be kept in large numbers under the trees early in the season this insect seldom does much injury.

THE PLUM-LEAF NAIL-GALL (*Phytoptus* sp.)

The leaves of the American varieties of the plum are sometimes injured by the production of a large number of slender tubular projections standing out from their upper surfaces as shown in the accompanying illustration. Inside each gall is a large number of very small spider-like insects or mites of the appearance of Fig. 19.



A B

Figs. 18 and 19.—A, plum leaf showing the galls; B, one of the galls enlarged and cut to show the interior.

Remedies—Probably nothing can be done of much value while the leaves are on the trees. Fallen leaves should be destroyed as far as possible by fire and the trees should be sprayed during the winter or early spring with

Fig. 20.—One of the mites that produce the nail-galls on plum leaves greatly enlarged.

kerosene emulsion of double strength (an emulsion in which the kerosene is about one-seventh of all), or whale-oil soap in the proportion of 1 pound to 4 gallons of water.

PLANT LICE.

For all plant lice attacking the plum, use the remedies recommended for the Apple Aphis. Apply the mixtures with considerable force so as to thoroughly wet the bodies of the lice.

The following insects, treated in this bulletin, also attack the plum: The Pear Slug, Tent Caterpillar, Fall Webworm, Red Spider, Brown Mite, Peach Borer, Grape Leaf-hopper, San Jose Scale and Putnam's Scale.

PEACH-TREE ENEMIES.

THE PEACH BORER (*Sannina exitiosa* Say.)

A yellowish white larva, or borer, working beneath the bark at the crown of the tree and down on the roots causing the exudation of a gummy substance. The eggs are laid about the crown of the tree by a small moth with narrow steel-blue wings that flies in the bright sunshine and much resembles a wasp in appearance.

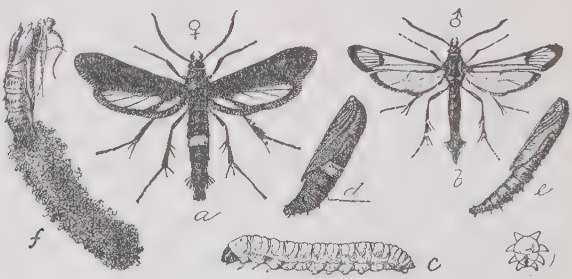


Fig. 21.—Peach tree Borer: a, adult female; b, adult male; c, full-grown larva; d, female pupa; e, male pupa; f, pupa skin and cocoon. All about natural size. (Marlatt, Circular 17, Second Series, U. S. Dep. of Agr. Div. of Entomology.

Remedies—Wherever the gummy exudation is seen, cut out the borer with a knife. This should be done early every spring, without fail, and if thoroughly attended to, will keep the insect in check. A little dirt should be brushed away from the the crown of the tree to discover any burrows that may not be apparent at the surface. Many preventives have been recommended to keep the female moth from depositing her eggs upon the trees. Wrapping the trunks of the trees to a height of 8 or 10 inches with tarred paper is probably as good as any of these.

Any of the following insects mentioned in this bulletin may also be found attacking the peach: Plum Curculio, San Jose Scale, Red Spider, Brown Mite and Plant Lice.

CHERRY-TREE ENEMIES.

The insects mentioned in this paper that may also be found attacking the cherry are: the Fruit-tree Leaf-roller, Tent Caterpillar, Fall Webworm, San Jose Scale, Brown Mite, Pear Slug and Plum Curculio.

THE ACHEMON SPHINX. (*Philampelus achemon* Drury.)

The young larva has a long horn on the last segment of the body while the fully grown worm only has a shining black spot. The eggs are deposited early in July on the leaves of grape and Virginia creeper. The larvæ soon hatch from them and feed on the leaves until about the last of August when they become fully grown and descend to the ground to pass the winter in the chrysalis.

Remedies—The worms are so large that they are readily seen and can be collected by hand and destroyed. They may also be destroyed by the use of Paris green or London purple sprayed or dusted on the leaves or, when unsafe to apply poison, by the use of Pyrethrum.

INSECT ENEMIES OF VIRGINIA CREEPER.

The foregoing enemies of the grapevine also attack the Virginia creeper and the remedies to use are the same in both cases.

INSECT ENEMIES OF SMALL FRUITS.

THE EIGHT-SPOTTED FORESTER (*Alypia octomaculata* Fab.)

The larvæ of this insect are common upon the grape vines in July and again in September. They are marked with numerous white, black and reddish cross-lines. On the middle segments of the body there are about eight black and seven white cross-lines to a segment and a broader reddish line on the middle of the segment. Low on the sides of the body and back of the three anterior pairs of legs there are rather irregular white blotches. When fully grown the larvæ are about one and one-half inches long.

The moth spans a little more than an inch from tip to tip of wings, and is black in color with two large cream colored spots on each fore wing and one large and one small white spot on either hind wing, the large spot being at the

base of the wing. The moths fly in May and again in the early part of August.

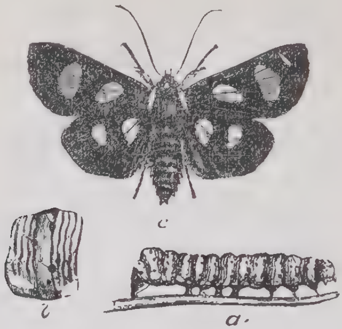


Fig. 22.—Eight spotted Forester: a. larva; b, one segment of body of larva enlarged; c, moth. Natural size except b.

Remedies—When safe to use poisons, spray thoroughly with Paris green or London purple. If there is fruit nearly grown so as to make the application of poison unsafe, use a bellows duster and make a thorough application of Buhach (Pyrethrum.)

This insect also attacks Virginia creeper badly.

THE GRAPE LEAF-HOPPER. (*Typhlocyba comes* Say.)

A very small jumping insect about one-eighth of an inch long and light yellow in color beautifully marked with red and black. When abundant, these hoppers will fly from the vines in large numbers when the latter are jarred. They cause the leaves to turn pale and sometimes they will even turn brown and curl up. In early spring, before the grape leaves open, these insects sometimes occur in enormous numbers on strawberries and I have also seen them in considerable numbers on currant and gooseberry bushes and upon Virginia creeper.

Remedies—Spray forcibly with kerosene emulsion early in the morning, before sunrise. At this time the hoppers are dumpish and can be easily knocked off the leaves with the spray and wet down with it.

When abundant on strawberries early in the spring it is very important to make a thorough treatment of the emulsion as above, or, if the vines have not started too much, spread a light covering of straw over the patch and burn it.

THE IMPORTED CURRANT BORER. (*Sesia tipuliformis*, Linn.)

Piths of currant stems burrowed out by a yellowish white larva about half an inch long. Before maturing the larva eats a hole to the outside. Bored stems sometimes wilting and dying and sometimes breaking down as the result of the injury.

Remedy—Cut out the infested stems and burn them before the first of June each year.

THE NATIVE CURRANT SAW-FLY. (*Pristiphora grossulariae* Walsh.)

A green larva, about half of an inch long when fully grown, feeding upon the leaves of currant and gooseberry bushes. Appearing late in June and again about the last of August. The adult insect is a black four-winged fly about the size of a house-fly. The eggs are deposited, one in a place, under the epidermis of the leaves.

Remedies.—The best remedy for this pest is white hellebore dusted lightly over the foliage in the evening. If this is carefully done, nearly every larva can be found dead under the bushes the next morning. Paris green or London purple may be used either dry or in water as for other leaf-eating insects. The latter poisons should not be used before the currants are picked.

THE WESTERN CURRANT AND GOOSEBERRY SPAN-WORMS. (*Thamnonoma*, sp.)

Light yellow larvæ, about one inch long when mature, and looping their bodies when walking. Sometimes completely stripping the foliage from the bushes.

Remedies.—Dust or spray Paris green or London purple as for other leaf-eating insects, or dust freely with Buhach (Pyrethrum). A thorough spraying with kerosene emulsion would probably be equally effectual.

Other insects mentioned in this paper that attack currants and gooseberries are: Red Spider, Tent Caterpillar, Fruit-tree Leaf-roller, Grape Leaf-hopper and Grasshoppers.

STRAWBERRY LEAF-ROLLER. (*Phoxopteris fragariae*, W & R.)

Small yellowish-brown to greenish larvæ, attaining nearly one-half inch in length when fully grown, and having the

habit of folding the leaves of the strawberry vines for their protection. When abundant they almost completely defoliate the vines. There are two broods, one appearing late in June and another in August.

The mature insect is a small rust-colored moth with more or less white and black markings on the wings and spanning about half an inch from tip to tip of wigs.

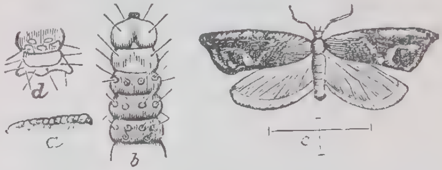


Fig. 23.—Strawberry Leaf roller: a, larva natural size; b, head end of larva enlarged; c, moth about twice natural size; d, tail end of larva enlarged. (After Riley).

Fig. 24.—Strawberry leaves showing their appearance when folded by the roller. (After Weed).

Remedies.—This is a rather difficult insect to manage as it is not safe to use the arsenites on the plants for the first brood. When the larvæ first appear, dusting the foliage lightly with white hellebore will destroy many of them. When the second brood appear, and the berries have been

picked, apply Paris green in flour dusting it thoroughly over the leaves in the evening when there is some dew on. An application very early in the morning will do equally well. Mix the poison and flour in the proportion of about 1 to 20 by weight and dust from a cheesecloth sack.

This insect has been reported quite abundant about Rocky Ford, this state, and it is the only place that I know it to occur in Colorado.

The other insects mentioned in this paper that attack the strawberry are: Red Spider, Apple Flea-Beetle and the Grape Leaf-hopper.

INSECT ENEMIES OF ROSE BUSHES.

THE RED SPIDER. (*Tetranychus*, sp.)

This insect is seldom abundant enough to do appreciable harm to orchard trees, but often becomes a serious pest on rose and currant bushes, sweet peas and other low plants. Although called "Red Spider," it is seldom red in color, but nearly always pale green with about three dark blotches on either side of the body. It is spider-like in appearance and is so small as to be seen with difficulty without the aid of a magnifying glass. It inhabits, chiefly, the under side of the leaves.

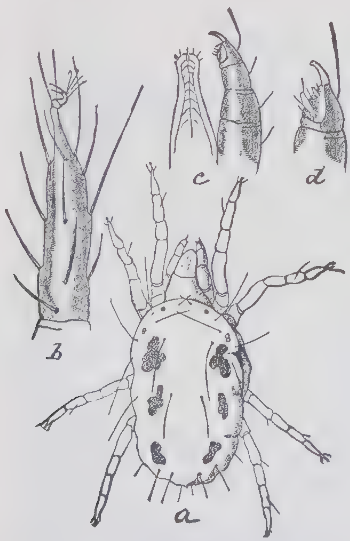


Fig. 25.—Red Spider: a, view from above, adult; b, one of the feet showing claw; c, the beak and one of the feelers or palpi; d, the end of the palpus more enlarged. All greatly enlarged. (Riley, Insect Life, Vol. II, U. S. Dep. of Agr. Div. of Entomology.)

where it works beneath a very delicate web which it spins. In this respect it differs from the Brown Mite which does not spin a web. The eggs are deposited under the web and are globular and transparent.

Remedies.—This insect thrives best in a dry atmosphere and the free use of water is probably as good a remedy as has been found. Apply often in the form of a spray taking pains to treat the under side of the foliage.

In addition to the above, the Fruit-tree Leaf-roller and a Plant Louse also attack the rose. I have also been informed that the Rose Slug, an insect resembling the Pear Slug, has become a pest in Denver. The remedies for it are the same as for the Pear Slug.

SHADE-TREE ENEMIES.

THE BOX-ELDER LEAF-ROLLER. (*Cacœcia semiferana*, Walk.)

This insect is a close relative of the Fruit-tree Leaf-roller and it is quite commonly thought not to be different. It seems to confine its attacks exclusively to the box-elder, however, in this state, as I have never yet found the larvæ feeding upon anything else. Its habits and appearance are much like the fruit tree species.

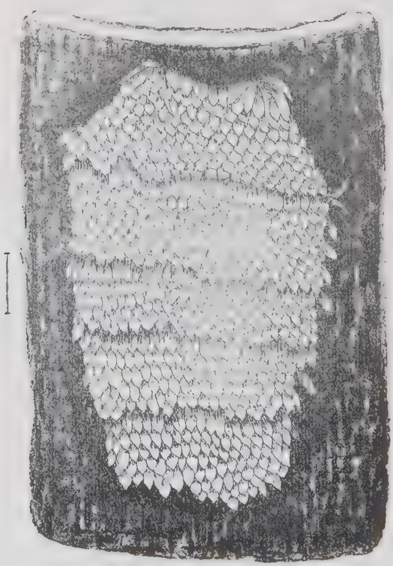


Fig. 26.—Egg-patch of Box-elder Leaf-roller, greatly enlarged to show the arrangement of the scales.

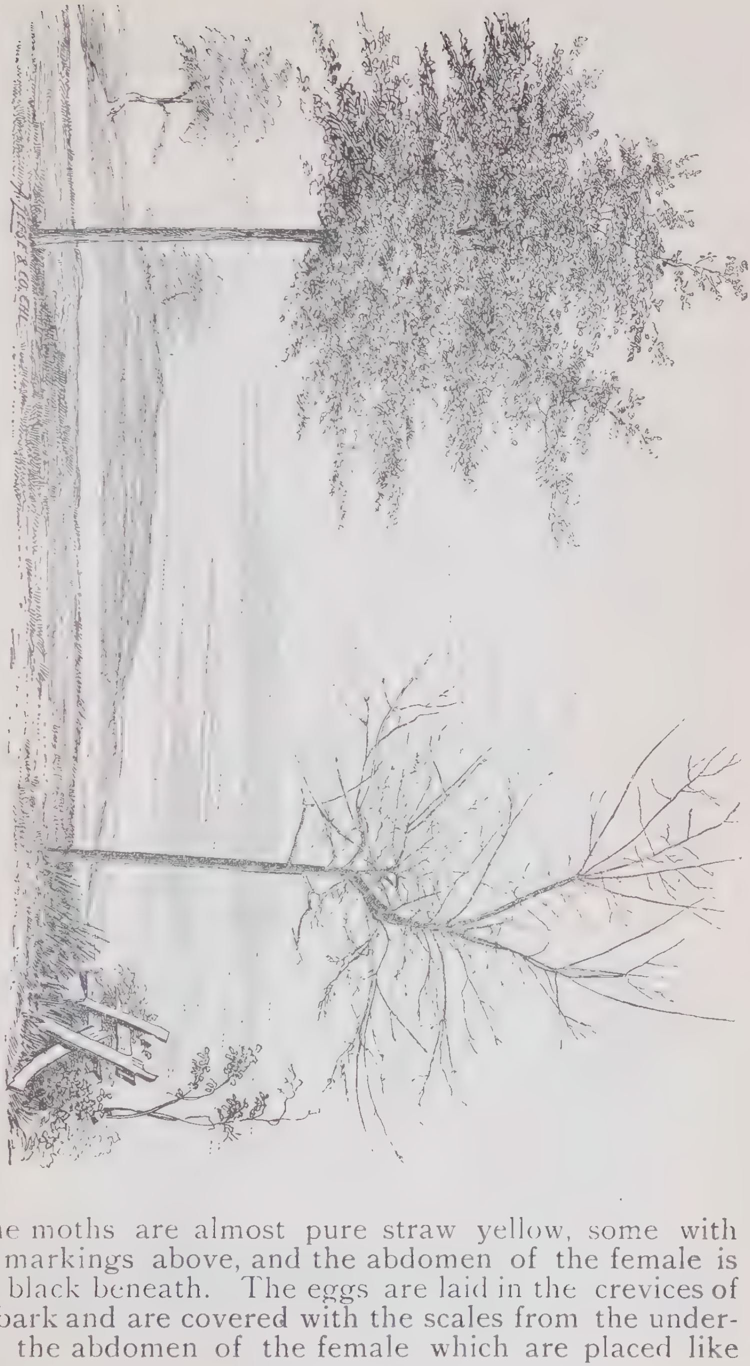


Fig 27. Two trees that were standing side by side, the one at the right untreated and the foliage all eaten off; the one at the left treated with Paris green and the foliage saved. From photograph by the author.

The moths are almost pure straw yellow, some with dusky markings above, and the abdomen of the female is largely black beneath. The eggs are laid in the crevices of rough bark and are covered with the scales from the underside of the abdomen of the female which are placed like

shingles upon a roof as shown in Fig. 26. The larvæ are light green or yellowish green in color and lack the black coloration of the head which is so distinct in case of the fruit tree species.

Remedies—The same as for the Fruit-tree Leaf-roller.

THE BOX-ELDER PLANT-BUG. (*Leptocoris trivittatus* Say.)

A rather flat bug, about half an inch in length, appearing black with narrow red margins to the thick portion of the wings and to the thorax, and with the body beneath the wings red. The adult bug lives over winter in protected places and often becomes very annoying in the fall and on warm days in the winter by crawling into dwellings. Often seen in large numbers on the south side of stone or brick walls in the sunshine and sometimes called "brick bug" in consequence. When warm weather in the spring comes on, the bugs go to box-elder trees and deposit their reddish eggs in crevices of the bark. The young feed chiefly on box-elder.

Remedies—Boiling hot water dashed upon the bugs when clustered upon buildings will destroy them. Ordinary

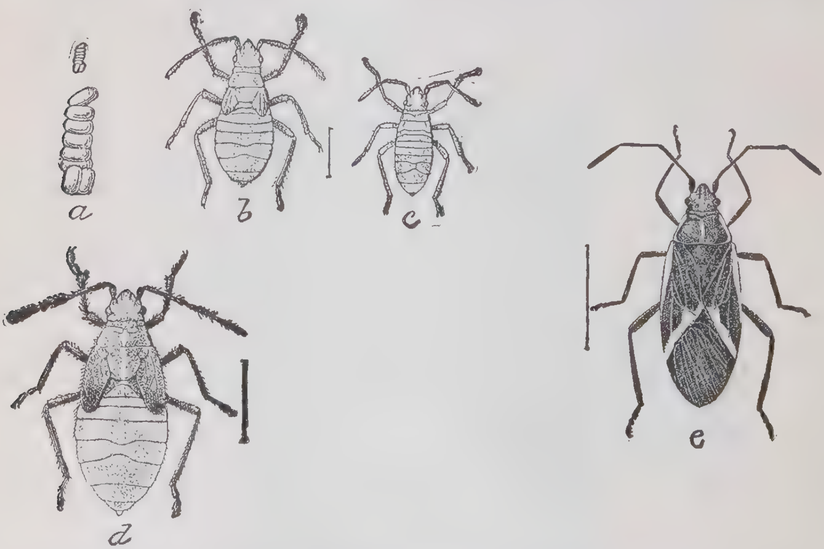


Fig. 28. - Box-elder Plant-Bug: a, eggs; b, c, d, different stages of the immature insect; e, mature insect. All considerably enlarged. [Howard, Circular 28, Second Series, U. S. Dep. of Agr., Div. of Entomology.]

applications for the destruction of these adult hibernating

bugs are useless. I have used kerosene emulsion, whale-oil soap, tobacco decoction, Zenoleum and Pyrethrum, all very strong, and with almost no effect except to make the bugs uncomfortable for a time. I do not know of any experiments having been tried upon the young but presume that kerosene emulsion or whale-oil soap of ordinary strengths will kill them if thoroughly applied.

The only other insect that troubles the box-elder badly in Colorado is the plant-louse (*Chaitophorus negundinis* Thos). Use the same remedies as for the Apple Aphis.

THE COTTONY MAPLE SCALE. (*Pulvinaria innumerabilis*, Rath.)

A yellowish or brownish oval scale on the twigs of soft maple. During the fall, winter and early spring the scales are quite flat, but, during May, the scales become convex and, finally, a mass of white cottony threads appear at one end, raising that end of the scale from the limb to an angle of about forty degrees or even more. In this cottony mass an enormous number of minute yellowish eggs are deposited, often as many as 2,000 to the single scale. It is at this time that the scales attract most attention on account of the cottony secretion.

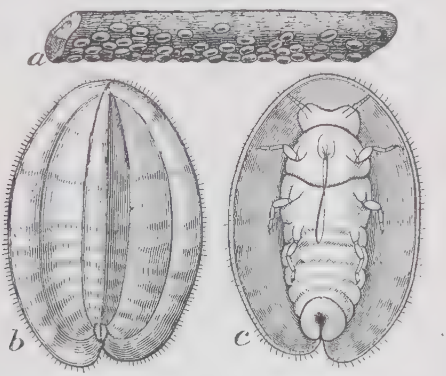


Fig. 29.—Cottony Maple Scale: a. eggs before hatching; b, egg after hatching; c. young larva; all much enlarged. (Riley, U. S. Dep. of Agr. Rep., 1884.)

Remedies—A thorough spraying with kerosene emulsion or whale-oil soap of ordinary strength will kill the young lice. If the application is delayed too long after hatching, the scales will so protect the lice that it will be

necessary to increase the strength of the mixture. If this is found necessary it will probably be better to treat as for the Scurvy Bark-Louse.

The soft maple is also attacked by the Fruit-tree Leaf-roller, Flat-headed Borer, Fall Webworm and Plant Lice.

THE ASH GALL-LOUSE. (*Pemphigus fraxinifolii* Thos.)

Greenish plant lice curling the leaves of white ash. The lice usually accumulate on the leaves at the end of a limb. The leaves curl and become so swollen and loaded with lice that the limb will often be bent down with the weight.

Remedy—As soon as the leaves at the end of the limb begin to curl, cut the limb off far enough back to include all the infested leaves and burn it.

THE COTTONWOOD BORER. (*Prionoxistus robiniæ* Peck.)

Fig. 30. Cottonwood Borer (*Prionoxistus robiniae*): Showing male and female moth and the larva. The female moth is the larger.

This insect is also known as the Oak Carpenter-Worm, but in Colorado it is known almost exclusively as a cottonwood borer. The larva, when fully grown, is nearly three inches in length, with a shining black head, and it cuts large holes in the trunks of the trees. Its work is most often noticed where a limb has been cut off or the trunk injured in some other way. The castings of the borers are pushed out on the surface and the tree bleeds as a result of the wounds made to the surface. The sap runs down on the trunk and sours, making a breeding place for maggots of certain flies. The moths have been taken at night at Fort Collins between June 14th and July 21. The females are larger than the males and both are well represented in the accompanying figure at about life size. The general color is gray, but the male has a large yellow spot covering the central portion of the hind wing on either side.

Remedies—It is hard to suggest a good remedy for this insect. Tacking a little wire gauze over the burrow before the middle of June would prevent the escape of the moth. Probably a wooden plug driven into the hole would serve the same purpose. With a stout wire one could kill many of the larvæ or pupæ in their burrows. Avoid scarring the trees as much as possible as the borers usually enter at such places.

The cottonwood is also attacked by Plant Lice, Fall Webworm and Putnam Scale, which have already been mentioned with their remedies. It is also attacked by a white scale (*Chionaspis ortholobis*), much resembling the scale figured on a following page on pine and spruce leaves. Remedies the same as for the other scales.

THE ELM LEAF-CLUSTER GALL. (*Schizoneura americana* Riley.)

The author's observations upon elms on the College grounds the present spring show that this louse appears on the trees before the leaf-buds begin to open, and that it attacks the base of a bud, soon becomes covered with a white flocculent secretion (see Fig. 32, e,) and that the bud, as it opens, curves downward so that the leaves hide the louse. The attack stimulates the opening of the bud and the growth of the leaves so that they are usually in advance of the other buds of the tree. By the middle of June, the infested leaves have formed a loose cluster, often as large as a man's fist or larger, within which is a disgusting mass of

lice and little globules of watery excretion that they have thrown off. Later the lice leave the galls, which become brown and dry, and go onto the leaves or tender bark about wounds on the tree. The leaves, as a result of the attack, become swollen and curled and usually take on a reddish coloration over the swollen portion.

Remedies—When the leaf clusters first appear, begin the work of cutting them off and destroying them. They occur mostly, on the small twigs near the trunk and on the lower branches of the tree. By going over the trees two or three times at intervals of about a week it will be possible to get nearly all before the lice spread over the foliage generally. It is stated by Riley that the eggs remain over winter on the trunk of the tree. If this is true, it is probable that a thorough spraying of whale-oil soap, 1 pound to 4 gallons of water, or kerosene emulsion, in which the kerosene is about one-fourth of the mixture, would kill nearly all the eggs.

The elm is also attacked by the Fruit-tree Leaf-roller, to some extent.

THE PINE-LEAF SCALE (*Chionaspis pinifoliae* Fitch.)

White elongated scales on leaves of pine and spruce trees are shown in the accompanying illustration. Beneath the scales, in the spring, will be found a mass of purple eggs. Sometimes very abundant, causing the leaves to fall, as many of them have from the twig of silver spruce shown in the figure. (See Fig. 34.)

Remedies—The same as for the Scurvy Bark-Louse of the apple. The best time to make the application is just after the young lice have hatched, which will be about the first of June. By the aid of a hand lens one can easily keep watch of the eggs and learn just when they hatch each year. The exact time will vary with the lateness or earliness of the season.

INSECT ENEMIES OF THE SPRUCE.

The scale mentioned above is quite as common on silver spruce in Colorado as on pine. The remedy, of course, is the same.

There are also two important plant lice attacking the spruce trees, one of which (*Chermes abietis* Linn.) produces brown cone-shaped galls at the tips of the twigs. The adult

females live over winter on the trees and deposit clusters of brownish eggs, all of which are attached to the twig or to each other by means of slender silken threads. The writer has found over 400 eggs in a single cluster. The eggs hatch about the first of June at Fort Collins and the young lice, according to the observations of Mr. R. A. Cooley of the Mass. Agricultural College, go at once to the bases of the young leaflets where they insert their beaks and suck the sap which causes the peculiar growth mentioned above. I have seen the galls on silver spruce, only, in Colorado, and have seen them most abundant near timber line on the mountains.

Remedies —Probably the best remedy is to collect and destroy the galls during the latter half of June and early in July, before the lice escape from them. Where very abundant, it would pay to make an application of kerosene emulsion or whale-oil soap in about double the ordinary strengths during the latter half of May.

What appears to be another species of *Chermes*, lays its eggs in great numbers on the leaves of Douglass spruce during the month of May. The female, while laying the eggs, secretes a quantity of white waxy threads which so surround the egg-clusters that the latter are hardly visible. The eggs hatch at Fort Collins about the 25th of May and the little dark-colored lice locate on the leaves. A twig showing these egg-clusters covered by the waxy secretion of the lice is shown in the accompanying illustration. (See Fig. 35.)

Remedies—I have been completely successful in destroying both eggs and lice by applications of either kerosene emulsion or whale-oil soap in double the ordinary strengths. In the ordinary strengths, the majority of both lice and eggs were killed.

MILKWEED BEETLE. (*Tetraopes femoratus* Lecont.)

Injuring Young Nursery and Forestry Trees.

A plantation of young forestry trees set out on the College grounds by the Department of Agriculture, Division of Forestry, has been badly injured by the above beetle. My attention was first called to the injuries by Professor Crandall who brought me a specimen of the beetle doing the work. The beetle did the damage by cutting transverse gashes in the tender stems and in the petioles of the leaves. A great many gashes were usually cut in each stem, causing them to die or break over. In many of the gashes eggs

were deposited. Fig. 36 shows two of the beetles and stems of locust on which they are working. The drooping leaves were all dead and brown.

Remedies—These beetles seem to have come onto the little trees from a large patch of milkweeds that were close by. If the milkweeds had not been allowed to grow in the vicinity of the forestry plot it is probable that the trees would not have been injured.

INSECTS INJURIOUS TO FARM AND GARDEN CROPS.

THE SQUASH BUG. (*Anasa tristis* De Geer.)

A rather large bug, varying from one-half to three-fourths of an inch in length and varying in color from a grayish brown to a dull black color above and dingy yellow beneath. On account of their strong musky odor they are often called "stink bugs." The bugs begin to accumulate about various vines of the squash family, particularly the vines of the Hubbard and other winter squashes about the time the first true leaves appear. There are two broods, the adults of the second brood living over winter under rubbish.

Remedies—As this insect does its feeding by inserting a sharp beak and sucking the sap of plants, it is evident that it would be useless to apply a poison that has to be eaten to kill. For a considerable number of days before egg-laying

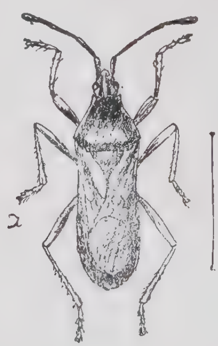


Fig. 37.—Squash bug enlarged. (After Snow.)

the mature bugs gather about the vines to feed and mate. Often they collect on a single leaf causing it to wilt. By visiting the vines each morning the bugs can be rapidly

crushed or collected and destroyed. This is really one of the best methods we have of keeping this insect in subjection. A little later the eggs, which are deposited on the under side of the leaves in loose clusters, can be quite rapidly destroyed by hand collecting. When the young hatch they have the habit of collecting in large numbers on single leaves. They are very shy and will run rapidly away when approached in the warm part of the day, but one can collect them rapidly in the morning about sun-rise. Take a basin or other suitable dish, with a little water in the bottom and a spoonful of kerosene on top, and go to these infested leaves and quickly brush the bugs into the basin. Every one that comes in contact with the oil will die in a very few seconds.

I have been able to kill large numbers of bugs with kerosene emulsion by spraying it forcibly upon them and thoroughly wetting them down, but in most hands the preceding remedies will prove most successful.

THE STRIPED CUCUMBER BEETLE. (*Diabrotica vittata* Fabr.)

A small yellow beetle, about one-sixth of an inch long with a black head and three black longitudinal stripes on the wings when the latter are closed. The beetles appear soon after the cucumber, melon and squash vines are up and eat holes in the leaves until the plants wither and die.

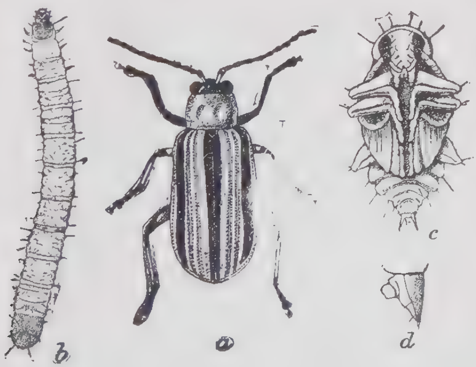


Fig. 38.—Striped Cucumber Beetle: a, mature beetle; b, mature larva; c, pupa; d, side view of last segment of larva. All considerably enlarged. (Chittenden, Circular 31, Second Series, U. S. Dep. of Agr., Div. of Entomology.)

Eggs are also laid about the stems of the plants and the grubs hatching from these burrow down into the roots of the plants which also causes their death.

So far, this insect seems only to occur in this state, along the Arkansas River from Canon City to Rocky Ford.

Remedies—There are many methods of dealing with this pest. One is to plant much more seed than is wanted to grow that enough of the plants may be left after the beetles have had what they want. Planting extra seed is all right, but more should be done. Dusting the leaves freely with lime, plaster or ashes in the evening or early morning, while the dew is on, will usually result in driving the beetles to some other patch, but will not destroy them. A method much practiced consists in covering the plants with mosquito netting until they are large enough to withstand the attack of the beetles. This may be done by tacking the netting over one end of open boxes that are then set about the plants, or by bending a withe over the plants, laying the netting upon it and holding it down by clods of earth.

I have found I can kill these insects very successfully by dusting Pyrethrum or Insect Powder upon them from a cheesecloth sack. To be successful the treatment must be made before sun-rise in the morning. Then, by lightly brushing the leaves, the beetles, damp and sluggish with the dew of the night, will fall to the ground and, if dusted in this condition with the Pyrethrum, will be readily killed.

THE MELON LOUSE. (*Aphis cucumeris* Forbes.)

A greenish louse occurring in great numbers on the underside of the leaves of watermelon, muskmelon, cucumber and squash vines, causing them to curl and turn yellow.

Remedies—It is so difficult to get insecticides upon this louse that there are no satisfactory remedial measures known for it. It is probable that its attacks can be avoided to some extent by a judicious rotation of crops and by plowing under the vines of infested patches as soon as the crop has been gathered.

FLEA-BEETLES.

There are several species of minute flea-beetles usually black in color and not as large as the head of an ordinary pin, which attack various garden plants, principally cabbages, radishes, beets tomatoes and potatoes. The damage is done by eating small holes in the leaves. When approached, the beetles jump and hence the name "flea beetles."

Fig. 39.—Striped Flea-Beetle (*Systena taeniata*) greatly enlarged.

Remedies—The same as for the Striped Cucumber Beetle.

THE BEAN BEETLE. (*Epilachna corrupta* Muls.)

This is by far the most destructive bean pest in Colorado. The mature insect is a beetle about one-third of an inch in length and yellowish to rusty brown in color with sixteen small black spots on its wing covers. The beetles deposit their yellow eggs in patches on the underside of the bean leaves. The grubs are light yellow in color and are covered with stout branched spines. The insect, in all stages, feeds upon the leaves and green pods of the cultivated beans and particularly wax beans. Lima beans are seldom badly eaten by them. See Fig. 40.

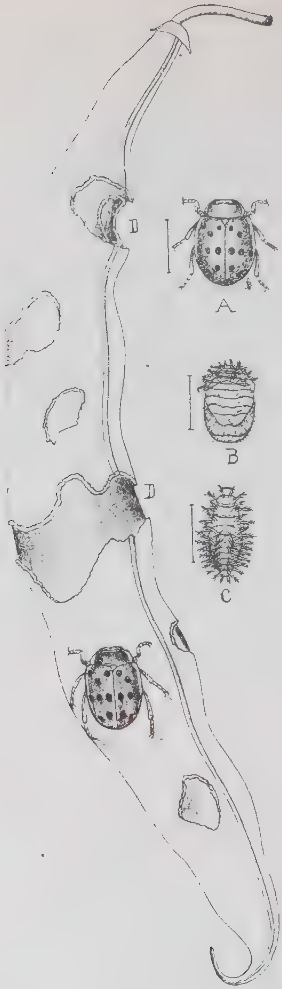


Fig. 40.—A, beetle; B, pupa; C, larva; D, a pod that has been eaten into. All a little enlarged.

Remedies—On account of beans being very susceptible to injury from the application of arsenites, it is rather difficult to treat this insect with satisfactory results. If the arsenites are used, lime should be freely added. I have had best success by using kerosene emulsion of double strength (in which the kerosene is one-eigth of the mixture), spraying it on the underside of the leaves for the destruction of the eggs and newly hatched grubs.

THE PEA WEEVIL. (*Bruchus pisi* Linn.)

This is the insect that causes what are known as "buggy peas," and by most people it is only known in the beetle state, in the spring of the year, when it is found in the peas or the peas are found to have large holes in them made by the weevils. These beetles lay small yellow eggs on the pods of the green peas and the little grubs hatching from them eat through the pod and enter the peas and are often devoured in great numbers by those who eat green peas. If the grubs have entered the peas the fact can be discovered by the presence of very small punctures as if made by the point of a needle.

Remedies—As soon as the green peas have been gathered, pull the vines and destroy them by fire or otherwise.

For the destruction of the beetles in seed peas inclose the seed in a tight receptacle and use carbon bisulphide, about one tablespoonful to a cubic foot of space. Continue the treatment for 24 hours.

THE COLORADO POTATO BEETLE. (*Doryphora 10-lineata* Say.)

This beetle, so common upon potato vines, is too familiar to the farmer to need any description. In this state it is also common upon its native food-plant, the "buffalo bur" (*Solanum rostratum.*)

Fig. 41.—Colorado Potato Beetle: a, a, egg patches; b, b, young larvæ; c, pupa; d, mature beetle; e, the fore wing much enlarged to show markings.

Remedies—Paris green or London purple dusted or sprayed upon the potato vines are so efficient remedies that no others need be mentioned.

THE ONION THRIPS. (*Thrips striatus* Osb.)

A very small insect, slightly yellowish in color and one twenty-fourth of an inch in length, very active and mature, occurring upon onion tops in enormous numbers, causing them to whiten and wilt down prematurely. The insects

Fig. 42.—Onion Thrips, adult, greatly enlarged.

are so minute that it is often the case that the cause of the dying down of the tops is not discovered by the owner of the crop.

Remedies—At the beginning of the attack thoroughly spray the onions with kerosene emulsion or whale-oil soap of the ordinary strengths.

CABBAGE APHIS. (*Aphis brassicae* Linn.)

A green plant louse on the underside of the leaves of cabbage, cauliflower, turnip and similar plants. The bodies of the lice are covered with a fine whitish powder, often occurring in enormous numbers late in the summer and in the fall.

Remedies—Kerosene emulsion and whale-oil soap are the standard remedies against these as well as other plant lice. It is difficult to make the application effectual, however, on account of the curling of the leaves of the plants that the lice infest and the mealy covering to the lice which causes all liquids to run from their bodies as water runs from a duck's back. To be effectual the application must be made with sufficient force to knock the lice from the leaves, in which case most of the lice will be killed. The lice live

over winter upon cabbages or their stumps that are left in the field in the fall. These should all be plowed deeply under or otherwise destroyed in the fall. An additional precaution of considerable value is to rotate the crop so as not to grow a crop nearer than necessary to ground where the lice were present the preceding year.

THE IMPORTED CABBAGE BUTTERFLY. (*Pieris rapae* Linn.)

This insect in the mature state is a white butterfly with black tips to the anterior wings and the male usually has four and the female six small black spots on the wings above as shown in the accompanying illustration.

The butterflies appear early in the spring and are ready to begin laying eggs on leaves of cabbages, cauliflowers, turnips and some other Cruciferous plants as soon as the plants are set out. The eggs are light yellow in color and are deposited singly. The worms, soon after hatching, assume a dark green color, almost identical with that of the leaves which serve as their food. Not infrequently the worms eat into the head of cabbages and ruin them for the market.

Fig. 43.—Imported Cabbage Butterfly: A, male; B, female. As seen from above, natural size. (After Riley.)

Remedies—Mix one pound of Paris green with twenty pounds of wheat flour and lightly dust the leaves while the dew is on. Apply freely up to the time the heads begin to form and after that use rather sparingly on cabbage heads and not at all on cauliflowers. Do not use nearer than ten days to the time when the cabbages are to be harvested. If used freely when the cabbages are small, there will be little need of much being applied when the heads are nearly grown. If used as above directed there will be no danger from eating the cabbages. Cabbage leaves are all the time opening out so that the leaves that are a part of the head

one day will, a few days later, be standing up free from the head.

For those who object to using poison, I would recommend insect powder (Pyrethrum) which is the best used dry in a small bellows by means of which the powder is driven down among the bases of the leaves to reach all the worms. This substance must be put onto the worms in order to kill them.

If much poison has been used it will not do to turn stock into the patch to eat the leaves and stumps after the crop has been gathered.

THE CABBAGE PLUTELLA. (*Plutella cruciferarum* Zell.)

This insect is a small moth, less than half of an inch in length and with narrow wings that have a white inner margin and when closed make a conspicuous white line along the back as shown in the accompanying figure. The larvæ are correspondingly small and are very active, wriggling

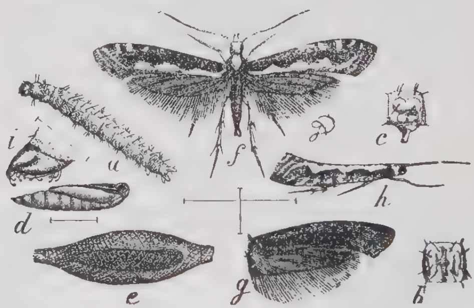


Fig. 44.—The Cabbage Plutella: a, larva; d, chrysalis; e, silken cocoon with chrysalis inside; h, moth with wings closed; f, moth with wings spread. All enlarged about twice. (After Riley.)

themselves quickly off the leaves when disturbed and dropping on a silken thread. When fully grown the larva spins a delicate white cocoon among the leaves. These I have found as early as June 10th at Fort Collins and the moths have appeared in our breeding cages as early as June 16th.

There are two, and perhaps three, broods in a season.

Remedies—The same as for the preceding species. Apply early so as to kill the first brood.

There are three other "worms" that feed upon cabbages to some extent in the state, but I will not give them special mention as the remedies are the same as for the species above mentioned.

CUT-WORMS.

Some dingy colored larvæ that burrow in the ground and have the pernicious habit of cutting off young plants of corn, beans, cabbages, tomatoes, etc., during the night.

There are a large number of species of these worms, each changing, finally, to a particular species of night-flying moth. It is very largely these moths that fly about lights in the evening.

Remedies—These worms are usually worst on newly turned sod. Probably the best field remedy is to plow late in the fall and then, in the spring, keep down all growing

Fig. 45.—Cut-worm Moth. (Riley, Rep. U. S. Dep. of Agr., 1884)

vegetation and scatter over the field a large number of small bunches of green vegetation (alfalfa, grass, cabbage leaves, weeds, etc.,) that has been thoroughly dusted with Paris green or London purple.

In gardens, individual plants of cabbage, tomatoes and the like may be protected by wrapping about them stiff paper or cylinders of scrap tin. The latter may be cut about five inches long by three inches wide and then wrapped around a hoe handle or similar object to give them form. Then separate the sides of the cylinder enough to admit the plant and crowd the tin into the ground enough to hold it firmly. Stiff paper may be used instead of the tin. Do not hoe the garden too clean of weeds while cultivated plants are small as the cut-worms like the weeds as well as anything for food. If the latter are all cut down there is nothing but cultivated plants for them to feed on. This may seem to be questionable advice, but it will work well if the weeds are not neglected too long, so as to choke the other plants.

GRASSHOPPERS.

The loss to crops from the attacks of grasshoppers is annually very large in this state. Even the dry pasture lands in many places support a horde of these greedy ma-

rauders that would be appalling to an eastern agriculturist. No description is necessary to enable my readers to recognize a grasshopper. The species that does by far greatest harm to farm and garden crops in Colorado is the large two-stripped grasshopper (*Melanoplus bivittatus*).

This and several closely related species deposit their eggs in little pouches or pockets in the ground in the man-

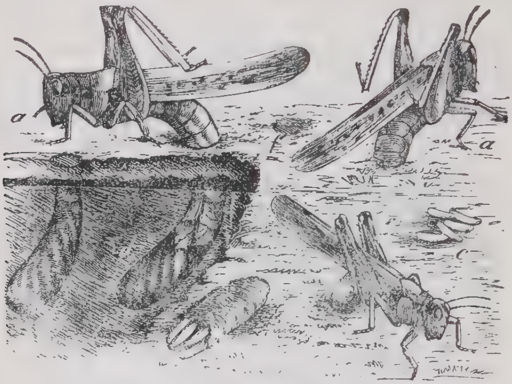


Fig. 46.—Rocky Mountain Locust laying eggs: a, a, females with their abdomens inserted in the ground; b, an egg-pod broken open; c, scattered eggs; d, egg-packet being formed by female; e, egg packet completed. (After Riley.)

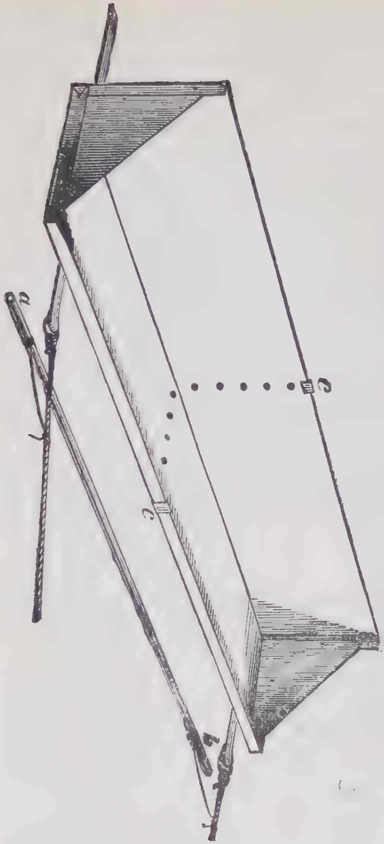


Fig. 47. Hopper pan or "hopperdozer." (After Riley.)

ner shown in Fig. 46. These eggs are mostly deposited about the borders of the fields, along ditch banks and along road sides where the earth is rather firm. They are deposited in the fall and the little hoppers hatch out early the following spring. There is but one brood a year.

Remedies—Where it can be used, the hopper pan or "dozer" is one of the best means of destruction. Fig. 47 will give an idea how these can be made. Make the bottom of the pan eight to twelve feet long, about eighteen inches wide and two inches deep. Have a back to the pan about eighteen inches to two feet high of canvas to prevent the grasshoppers from jumping over. Mount the pan on low runners and draw it over the field with horse power where the grasshoppers are most abundant, first putting in

the pan a strip of cloth reaching the whole length and pouring upon it at least a pint of kerosene. The canvas at the back of the pan should also be kept wet with the oil. This plan of using the hopperdozers is as used by Dr. Lugger who has had a large amount of experience with them in Minnesota. Every grasshopper that comes in contact with these cloths and gets the oil upon any portion of itself will soon die. As the oil evaporates more must be added.

In orchards, vineyards and gardens where the pans cannot be used, poisoned baits made by mixing one pound of Paris green with six to ten pounds of bran, with just water enough to moisten the whole, may be prepared and scattered about in small quantities where the hoppers are thickest. Many will eat the poisoned bran and die. Paris green or London purple may also be sprayed on the food plants of the grasshoppers where it is safe to use it. Care must also be exercised in the use of poisoned bran that chickens and other domestic animals may not be poisoned.

THE MEDITERRANEAN FLOUR-MOTH. (*Ephestia kuhniella* Zell.)

This insect has attracted attention in this country and in Europe almost exclusively as a pest in flouring-mills. My attention was first called to the insect in Colorado on September 14th, 1893, when I received some honey comb from Mr. R. C. Aikin of Loveland, which was very badly infested with the larvæ and webs of this insect. The moths were also appearing at the time. The moth is gray in color with narrow wings and spans about three-fourths of an inch and is very well represented, at Fig. 48. Fig. 49 shows the appearance of the webs on a frame of honey comb.

Fig. 48.—Mediterranean Flour-Moth: a, moth with wings spread; b, moth with wings closed; c, larva; d, chrysalis; e, two segments of the larva greatly enlarged. All somewhat enlarged. (Riley & Howard, Insect Life, Vol. II, U. S. Dep. of Agr., Div. of Entomology.)

The larvæ seem not to feed upon the honey or wax but upon the old pollen left in the cells, though they will often gnaw through the thin walls of the cells to get from one into another. This insect does not trouble the combs in hives occupied by bees but only combs that have pollen and are stored away for future use.

Remedy—Inclose the infested combs in a tight box with carbon bisulphide. Use a teaspoonful of the liquid to each cubic foot of space in the box.

To destroy the worms in mills, use about one quart to each 1,000 cu. ft. of space. Always be careful not to bring fire in contact with the fumes as they are explosive when mixed with air.

ANTS.

Ants often become troublesome in the pantry, the lawn or the apiary and many inquiries are received as to how they may be destroyed. Where the hill can be found, thrust a stake into it to the depth of about a foot, pour in two or three ounces of carbon bisulphide, stamp the hole full of dirt, and then throw a damp blanket over the hill to hold down the fumes. The fumes of the carbon bisulphide are explosive when mixed with air, so care must be used not to bring fire in contact with this substance unless for the purpose of exploding the fumes in the ant hill.

If the ants are troubling in the house, thoroughly dust the ants and their run-ways with insect powder (Pyrethrum.)

THE BED BUG. (*Acanthia lectularia* Linn.)

I take it for granted that this unwelcome guest of some of the homes of this country is not familiar to all my readers and so briefly describe it as a light yellow to dark brown bug, without wings, about one-fourth of an inch in length when fully grown, and very flat. The color and shape together has suggested to someone the very polite name "mahogany flat." Like other evil-doers, it avoids the light and is often unseen and not suspected in sleeping apartments where it is present in large numbers. Its hiding places are usually in cracks of the bedstead, under the binding of matresses, under wall-paper and similar places of concealment. In these places the eggs (nits) which are elongate white objects, of very small size, are deposited, sometimes in great numbers.

Fig. 50.—Bed Bug, much enlarged. (Osborn, Bull. 5, New Series, U. S. Dep. of Agr., Div. of Entomology.)

Fig. 51.—Bed Bug, young. (Osborn, Bull. 5, New Series, U. S. Dep. of Agr., Div. of Entomology.)

Remedies—Use bedsteads that will offer as few places as possible for the bugs to hide in. Have no loose paper on the walls under which the bugs can crawl. Put bedding and carpets and every other infested article, so far as possible, in boiling water. Pour boiling water into all places that can furnish concealment for the bugs so far as possible. By means of an atomizer or a small brush or feather apply gasoline, benzine or turpentine to cracks and crevices where the bugs or their eggs might be concealed. If these means have not been sufficient, fumigate the house with sulphur or with carbon bisulphide. Candles for the purpose of fumigating houses can be obtained at almost any drug store.

It will not do to make one treatment of any kind and then think no more is to be done. Make several careful searches a few days apart and continue the warfare 'till no more vermin are found.

CLOTHES MOTHS.

There are few insects that give housekeepers more annoyance than the clothes moths. There are but two species that give much annoyance in houses in this country and they are of a yellowish or buff color, with narrow wings and slender bodies, and when spread will span but little more than half an inch from tip to tip of the wings. They are often seen as very small moths flying about the room after lamps are lighted. The large moths that often fly to lights in our houses and flutter about on our windows, are frequently supposed to be clothes moths, but they are not.

The clothes moths feed upon animal tissue as hair, feathers and wool, but do not attack cotton or linen goods.

Remedies -The frequent airing and beating of garments and carpets is one of the most effectual remedies. When clothing is laid away for the summer it may be put in tight paper sacks or in pasteboard boxes made tight by wrapping, or in any other moth-tight receptacle where the moths or their eggs are not already present. To make sure that no eggs were deposited on the clothing before it is put away, it should be examined once or twice to see that it is all right. The lighter the room where the clothing is stored the better, as clothes moths delight to work in dark rooms and closets, but seldom do much harm in rooms that are well lighted and aired. If clothing is thought to be infested, all moths, eggs and larvæ can be killed by placing the clothing in a tight box and pouring in carbon bisulphide and then closing tightly for a few hours. If the moths in any stage are about the borders of the carpet, they may be destroyed by spreading damp clothes over the infested places and then ironing them with hot flats.

Moth balls, camphor, tobacco and cedar wood are used to repel the moths and are quite useful for this purpose, but if the insects are already present these things do not prevent their living and doing their usual injuries.

THE CARPET BEETLE. (*Anthrenus scrophulariae* Linn.)

A small, dark-colored beetle, about three-sixteenths of an inch long and marked on the wing covers with white and a slight amount of reddish. The larva is dark brown in color and is rather heavily fringed with hairs, especially at

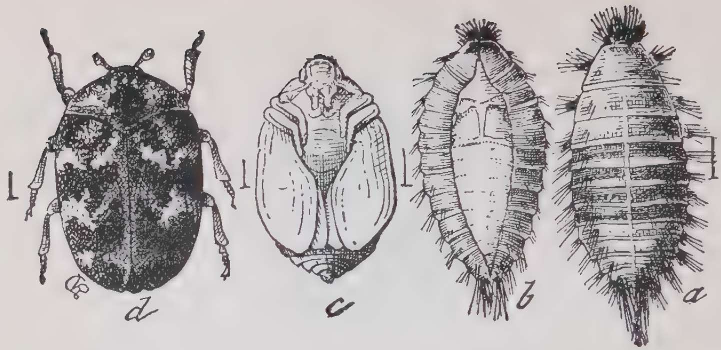


Fig. 52.—Carpet Beetle or Buffalo Moth: a, larva; b, pupa within the larval skin; c, pupa removed from larval skin; d, adult beetle. All greatly enlarged. (After Riley)

the tail end end of the body. It works most about the borders of carpets and along cracks in the floor. It is most commonly known as the "Buffalo Moth," but it is not a moth at all but a beetle.

Remedies—This household pest is more difficult to rout than the clothes moths above mentioned. The treatment is the same but needs to be more vigorously and persistently applied. If very troublesome it will be found best to do away with carpets and use rugs instead, the rugs to be frequently removed from the house and beaten.

INSECTICIDES.

An insecticide may be defined as any preparation which can be used for the destruction of insects. Insects are animals and the substances that will kill animals of large growth will, as a rule, kill insects also.

In order to apply insecticides intelligently one should know the principle underlying their use, then he does not have to be bound by any fast rule. These principle are so simple that I will give them.

We may separate the insect-destroying substances into

THREE CLASSES,

depending upon the manner in which the death-dealing work is done.

First, and most important among these, are the food-

poisons, or those substances which kill by being eaten. It must be evident to all that these can only do harm to insects that devour the tissue of the plant, nearly always the leaves. Those insects that feed by inserting a sharp beak and sucking the sap of the plant can not be successfully combatted by the use of food poisons. Against them we must, as a rule, use some substance that will kill by external contact. There are, of course, a great number of preparations that would kill in this way but we have to use something that will destroy the insect without serious injury to the plant on which it is feeding.

It is not necessary that one be versed in the science of entomology in order to be able to determine into which of these two classes an insect that is doing damage to his plants belongs. If the foliage of the plant is being removed, or if the leaves are full of holes or ragged as the result of the insect attack, it is reasonably certain that the marauder has a good pair of jaws and is devouring the solid parts of the leaves; but, if the leaves only turn pale or brown and curl, and are not eaten into, it is then quite certain that the insect is doing the damage by extracting the juices of the plant. Examples of such insects are Plant Lice, Scale Lice, the Squash Bug, Chinch Bug, etc. Examples of the former class are Grasshoppers, Potato Beetles, Leaf Rollers, the Codling Moth, etc.

Then there are insects in both of the above classes that are best destroyed by the use of certain volatile substances which kill by being inhaled. As examples I might mention certain grain-eating weevils, ants, root-infesting lice, vermin in houses as Bed Bugs, and Clothes Moths, etc.

In its broadest sense the term insecticide is also made to include certain substances which are used only as repellants. These do not kill and are of much less value than either of the other classes. Napthaline, camphor and carbolic acid are examples of such substances.

PREPARATION AND USE.

It will be understood that almost any insecticide may need to be used in different strengths under varying conditions. In the following formulæ I give the ordinary prepations.

FOOD POISONS.

PARIS GREEN ; WATERY MIXTURE.

Paris green,..........................1 pound.
Lime (unslaked,)......................1 pound
Water,..........................160 gallons.

First thoroughly mix the poison in a small quantity of water and then add the remainder of the water. Slake the lime in a small amount of water and add to the mixture. If the lime is lumpy after slaking, strain it to avoid clogging the spraying nozzle.

PARIS GREEN ; DRY MIXTURE.

Paris green..........................1 pound.
Wheat flour,..........................20 pounds.

Apply, if possible, when the foliage is moist with dew and when there is no wind. If the plants are low, the mixture may be easily applied by inclosing it in a muslin sack which is shaken over the foliage.

Plaster, or lime may be used as a dilutent in place of the flour but the flour is considered best as it sticks the poison to the leaves causing it to remain longer.

LONDON PURPLE.

Prepared in the same ways as Paris green. It is somewhat cheaper than that poison but it is not considered quite as effective in destroying insects.

KEDZIE'S ARSENITE OF LIME.

Dr. R. C. Kedzie, chemist of the Michigan Agricultural College and Experiment Station, has given directions for making arsenite of lime and some who have used it prefer it to either Paris green or London purple. When prepared it is the same as the latter substance except the small amount of coloring matter which is accidental and serves in the London purple to distinguish it from substances that might be mistaken for food. Dr. Kedzie's directions are as follows :

"Boil two pounds of white arsenic and eight pounds of salsoda for fifteen minutes in two gallons of water. Put into a jug, label '*poison*' and lock it up. When ready to

spray, slake two pounds of lime and stir it into forty gallons of water, adding a pint of the mixture from the jug."

As white arsenic, salsoda and lime are all cheap substances, this is a very economical mixture. It may be used as a substitute for either of the preceding.

ARSENIC-BRAN MASH.

This preparation has been used almost exclusively for the destruction of grasshoppers in places where hopper-dozers can not be used. Prepare by taking

White arsenic (or Paris green) .... 1 pound.
Wheat bran .... 10 pounds.
Water................enough to make moist.

Scatter in small quantities in places where they will be most likely to find it.

Care must be used not to place the bran where it will be devoured by domestic animals.

BORDEAUX MIXTURE AND THE ARSENITES.

Bordeaux mixture is a fungicide and is the substance most often used for the destruction of fungi that attack the the surface of plants. It has also been found to be of value for use against flea-beetles and the writer also demonstrated its value a number of years ago as a medium in which to spray Paris green or London purple. These poisons can be used very strong in this mixture without injury to foliage and they do not, in the least, lessen its effects as a fungicide. Such a mixture would destroy both insects and fungi with one application.

The Bordeaux mixture may be prepared as follows: Take of

Copper sulphate.....................6 pounds.
Quicklime...........................4 pounds.
Water ....45 gallons.

Dissolve the copper sulphate in a gallon of hot water, slake the lime in another gallon of water and then add the milk of lime slowly to the copper sulphate solution while the latter is being constantly stirred. Then add 43 gallons of water.

If insects are to be killed at the same time, add to the above quantity of Bordeaux mixture, one-third pound of London purple or Paris green.

HELLEBORE.

Powdered white hellebore has been found particularly useful for the destruction of certain insects and may be applied dry or in water. If applied dry it may be used pure or diluted a few times with flour. I prefer to use the powder pure when the slightest dusting over the leaves in the evening when the dew is on is usually effectual. Inclose the powder in a cheesecloth sack and shake it over the plants.

If applied in water use

Hellebore	1 ounce.
Water	3 gallons.

EXTERNAL IRRITANTS.

It should be borne in mind that, in order to destroy an insect by an external irritant, the substance must be put upon the insect's body. Spraying the food will not answer.

KEROSENE EMULSION.

This preparation has no equal for the destruction of insects by external contact, so far as we know at present. The substances of which it is composed are always obtainable and the emulsion is not difficult to make after one has learned how. For the ordinary strength the proportion of the ingredients is as follows:

Soap	1 pound.
Kerosene	2 gallons.
Water	28 gallons.

Prepare by dissolving the soap in a gallon of water; while the soapy water is boiling hot, remove from the fire and immediately add two gallons of kerosene and agitate briskly for a few minutes. If a large amount is being made, use a force pump and forcibly pump the mixture back into the receptacle that contains it until all is a frothy creamy mass. If such a mixture is not obtained the first time, put the whole back over the fire until boiling hot and then repeat the pumping and the emulsion will almost surely form. If put back for reheating watch very closely to see that it does not boil over and take fire.

After the emulsion is made add the remaining 27 gallons of water and all is ready for use.

When small quantities are made, emulsify with an ordinary egg-beater.

To be sure of success, use clean dishes and clean water.

WHALE-OIL SOAP.

This substance stands close to kerosene emulsion in importance as a destroyer of soft bodied insects. It is used in various strengths, but the ordinary preparation is:

Whale-oil soap......................	1 pound.
Water..............................	8 gallons.

As a winter wash, it is sometimes used as strong as two pounds in a gallon of water for the destruction of San Jose and other scales. A pound to eight gallons destroys the eggs of plant lice or of the Brown Mite.

TOBACCO.

Tobacco has long been used in one way or another for the destruction of insects. Its chief use seems to be for the destruction of animal and plant lice. When slowly burnt, the smoke may be utilized for the destruction of lice on plants in green-houses or window gardens. In the form of a fine dust it is often effectual in ridding plants of flea-beetles and in the form of dust or stems is probably the best remedy we have for Wooly Aphis on the roots of apple trees.

I have a letter from the A. B. Mayer Manufacturing Co., of St. Louis, Mo., offering tobacco dust at $20.00 a ton f. o. b. cars in that city.

PYRETHRUM (Buhach, Persian Insect Powder.)

This substance, under one of the above names, can be obtained at almost any drug store. It consists of the dried flowers of two species of plants of the genus Pyrethrum which are ground into a very fine powder. The powder has the peculiar property of killing almost any insect that it comes in contact with while it is not poisonous to other animals. If applied in water use

Pyrethrum..........................	1 oz.
Water..............................	3 gallons.

In most cases I prefer to use this substance dry and un-

diluted and it may be distributed by means of blowers made for the purpose or by inclosing in a cheesecloth sack and shaking it over infested plants.

Its chief uses are for the destruction of plant lice, cabbage worms, flea-beetles, squash-beetles, ants, cockroaches and house flies.

LIME, SULPHUR AND SALT WASH.

The following preparation is a favorite one on the western coast for the destruction of scale insects and the Brown Mite. For the latter insect it is reported to be entirely successful about Grand Junction in this state. The following formula and method of preparation I quote from Circular 3, Second Series, Division of Entomology, Washington, D. C. The paper is by Dr. L. O. Howard:

Unslaked lime	10 pounds.
Sulphur	5 pounds.
Stock salt	4 pounds.
Water to make	15 gallons.

This wash will do great damage to the trees if applied during the growing season, and should be used only in winter. All the sulphur and half of the lime are placed in a kettle and 8¼ gallons of water added, after which the contents of the kettle are boiled briskly for about an hour. The solution, which at first is yellow from sulphur, will turn very dark brown, assuming more or less of a reddish tint, and will finally change from a thick batter to a thoroughly liquid condition, the product being ordinary sulphide of lime. All the sulphur is added to the remaining five pounds of lime and the latter slaked, after which the slaked lime and salt are added to the sulphide of lime already obtained, the whole being then diluted with water to make 15 gallons. This should be strained before application, as it does not form a perfect liquid solution."

INSECTICIDES THAT KILL OR REPEL BY BEING INHALED.

CARBON BISULPHIDE.

This is an extremely volatile liquid having a very disagreeable odor and its use must be attended with a good deal of caution as it is explosive when mixed with air and brought in contact with fire. It can be used to destroy any insect that can be got into a tight receptacle as a box, jar or room. It is also destructive to root-infesting insects and ants in hills when injected into the ground in proximity to the insects. When employed for the destruction of insects in tight receptacles, use about one quart to every 1,000 cubic feet of space and continue the treatment for 24 hours at least. If used in a building that is not very tight a somewhat larger amount might be required. For fumigating large rooms it is better to place dishes containing the liquid in the upper part of the room as the fumes are heavier than air and settle.

HYDROCYANIC ACID GAS.

This is a very successful remedy against scale insects in California and is used in the following proportions:

Cyanide of potassium, 60 per cent.,....1 ounce.
Commercial sulphuric acid,....1 ounce, (fluid).
Water..............................3 ounces.
Space inclosed,.................150 cubic feet.

The fumes given off are extremely poisonous and care must be taken not to inhale them. The tree to be treated is first inclosed in a tent or box, the water and sulphuric acid poured into a dish and set in, and then the cyanide added and the tent or box quickly closed and kept so for about one-half hour.

Figure 12.

Apple Plant Louse: Twig showing eggs. (From photograph by the author.)

Figure 29—A.

A twig of soft maple showing the cottony scales covering it along one side, the under side of the limb. (From photograph by author.)

Figure 29—B.

Cottony Maple Scale: Female scales on leaf and twig with the cottony secretion protruding. (Riley, U. S. Dep. of Agr., Rep. 1884.)

Figure 31.

Trunk of cottonwood tree showing the dark patches on the bark caused by the souring sap from the burrows of the Cottonwood Borer. (From photograph by the author.)

Figure 32.

Elm Leaf-cluster (*Schizoneura americana):* a, b, c, d, successive stages in the early development of the gall; e, the louse covered with cottony secretion at the base of the bud which is just beginning to curl. All natural size. (From photograph by the author.)

Figure 33.

Elm Leaf-cluster (*Schizoneura americana):* a, a, etc., a number of the clusters on an elm limb. Very much reduced. (From photograph by author.)

Figure 34.

Pine-leaf Scale (*Chionaspis pinifoliae* Fitch): A, the scales on leaves of silver spruce; B, scales on leaves of pine. (From photograph by the author.)

Figure 35.

Egg patches of plant louse (*Chermes sp.*) on Douglass Spruce. Each patch of eggs covered by a cottony secretion from the adult louse. Somewhat reduced. (From photograph by the author.)

Figure 36.

Injuries to small locusts trees by *Tetraoesp femoratus*: a, a, etc., gashes cut in the stems by the jaws of the beetle; b, b, beetles at work. (From photograph by the author.)

Figure 49.

A frame of honeycomb showing the cocoons and webs of the worms that were feeding on old pollen. (From photograph by the author.)

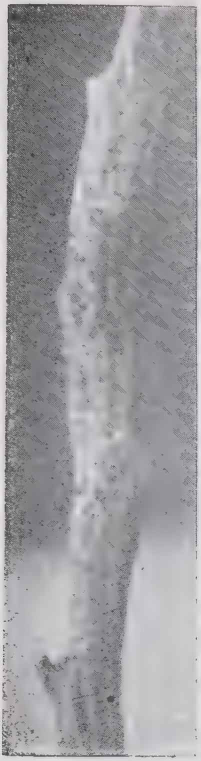


Fig. 12.

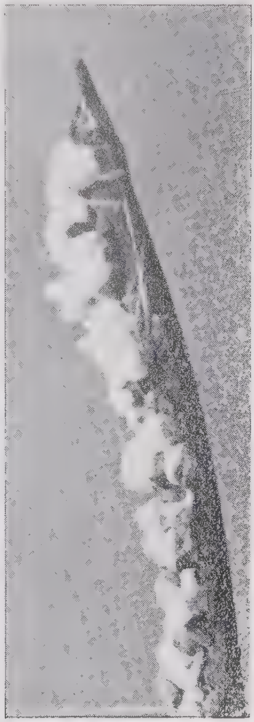


Fig. 29 B.

Fig. 29 B.

Pl. 34

Fig. 31.

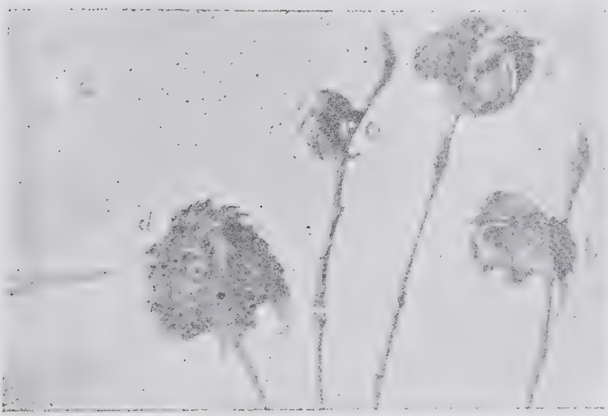


Fig. 32.

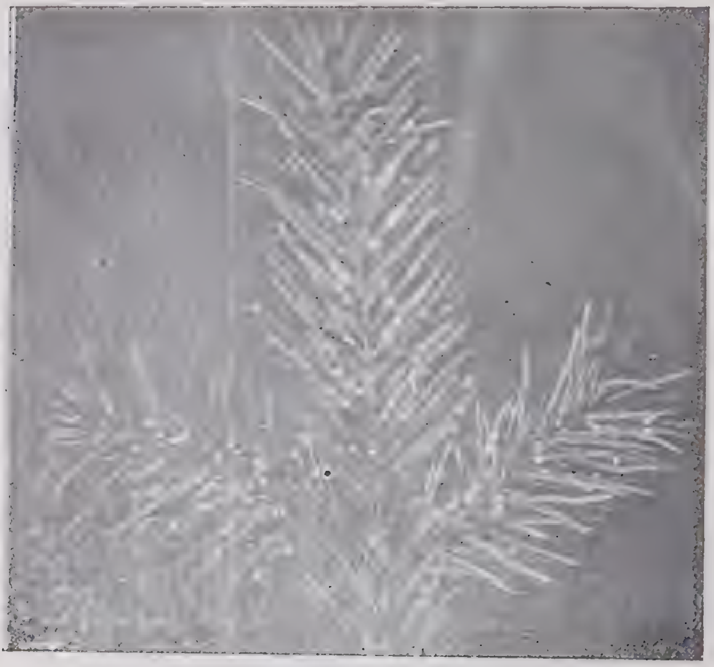


Fig. 35

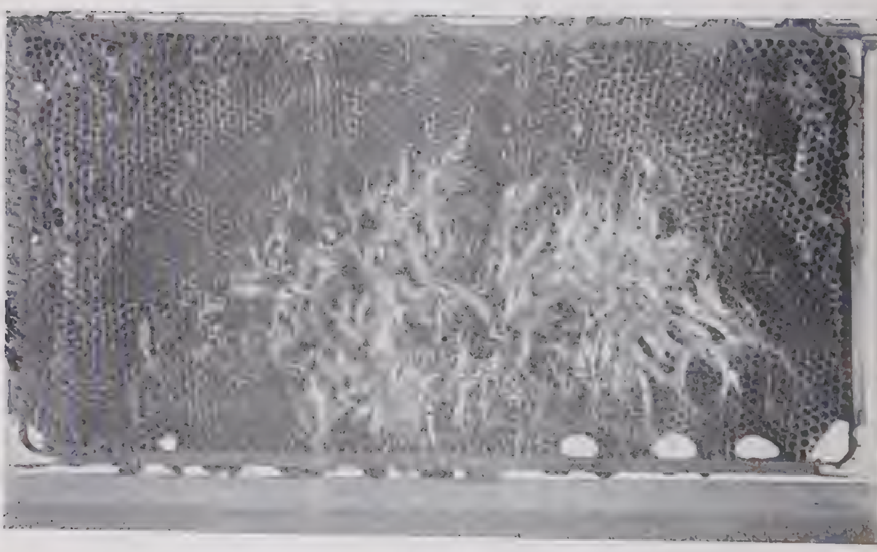


Fig. 19

Fig. 33.

Fig. 36.

ERRATA.

Page 4, line 6, for 21 and 48 read 22 and 46.
Page 4, line 9, for 17A read 17.
Page 18, line 8, for *a, antenna* read *b, antenna.*
Page 18, line 12, for *Pratensis*, read *pratensis.*
Page 64, line 6 from bottom, for *Tetraoesp* read *tetraopes.*
Page 65, for 29B under upper figure, read 29A.

The cut on title page is a duplicate electrotype obtained from the Div. of Entomology of the U. S. Dep. of Agriculture.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 48.

Losses from Canals from Filtration or Seepage.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

JULY, 1898.

EXPRESS, FORT COLLINS.

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FORT COLLINS, COLORADO.

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ON THE LOSSES FROM CANALS FROM FILTRATION OR SEEPAGE.

By L. G. CARPENTER.

The present bulletin is one of a series bearing on irrigation questions, and while suggested by the conditions in Colorado, it is not limited in its application to that State. The author has kept steadily in view the fact that Colorado has a limited supply of water and that the success of her individual farmer, as well as her agricultural extent, depends upon a clear understanding of the means of using water properly, of saving useless losses, and of the prevention of waste. While the author has believed that there are questions which might be more immediately useful to the individual farmer, he is fully convinced from a study of the development of other irrigated countries, that in the formative period of our development a more lasting benefit will accrue to the agriculture of the State by considering certain fundamental questions not so immediately applicable to individuals.

The present bulletin, however, has its immediate individual application. It is to some extent complementary to bulletin 33, on seepage or return waters from irrigation. While the earlier bulletin discussed the seepage or return waters entering streams, the present bulletin considers the losses from canals which, there is reason to think, is the principal source of the gain in the streams. If the connection between the canals and the streams is an intimate one, we may finally expect to find an approximate equality between the losses from the canals and the gains in the streams.

But more suggestive, the measurements here reported give an idea of the extensive losses involved in the carriage of water. The amount has been believed to be large, but when it is found that the leakage may become as much as 20 or even 30 feet in depth per day, it suggests the importance of taking steps to lessen the amount.

By stating the loss in the depths lost per day, a better

idea can be obtained even by those familiar with the terms of water computation.

The loss of water from canals and distributaries seems to be greater than the loss from irrigation into the soil. Many cases of leakage can be lessened with profit, thus saving considerable water, and much more water can be saved when its value is enough to warrant the expense.

While the author's conclusions are necessarily influenced by the cumulative effect of numerous observations difficult to fully summarise, the measurements throwing light on the subject under discussion, are presented with sufficient fullness to enable the reader to disagree with the writer if the facts do not warrant his conclusions.

The loss from canals is known to be large, and often produces a serious problem in their management. This loss is often the cause of unnecessary scarcity in the water supply, especially at the lower end of the canal during the season when water is low. It has sometimes been enough to cause canals or laterals to be abandoned. It has many times led to failure of crops and has always made a material decrease in the water supply. The serious nature of the loss has been understood by the farming community, and associations have sometimes discussed methods by which it might be lessened. But I am unaware of any serious attempt to locate the loss or to determine the amount.

While we have made occasional measurements on the losses from canals, the past year (1897), has been the first when systematic measurements could be made. Without attempting to develop the general law of the loss, the measurements on a number of canals under different conditions are given with such conclusions as the data seem to warrant. A knowledge of the facts is the first step toward finding the remedy, or even to decide whether a remedy need be sought.

It is hardly necessary to observe that the cases here given are specific ones, and the losses found in these cases, may or may not be the same on other canals. The similarity of conditions, especially the similarity of the canal bottom, gives a basis for judgment. In many cases the loss is undoubtedly less, in others more. Hence the need of caution in hastily assuming that these measurements apply to all cases. So far as the canals chosen represent average conditions, the measurements may be considered as averages. From these and from a larger number of cases we may hope to determine the probable losses and from more

extensive investigations obtain principles which may be applicable under new conditions.

The canals measured include stretches of canals in the Platte Valley and Cache a la Poudre valley near Fort Collins, and several in the San Luis valley, and one canal on which automatic records were kept for two years. The method of measurement was essentially the same in all cases, namely, to measure the amount flowing in the canal at different points, and then to compare the increase or decrease in the amount of water in the canal after allowing for the water taken out by laterals between the points of measurement. The measurements show that many of the canals, especially those deep in the ground, serve as drains during a portion of the year or for a portion of their course. This is often true where there are other canals on higher ground whose seepage drains into the lower canal. Some canals lose water in places and gain water in other places. We have thus found some stretches where the results differ from those anticipated. In some cases the loss from the canals was found to be very large.

The results suggest that it is desirable for many of the larger canals to determine their loss from seepage throughout their length and thus determine whether unreasonable losses take place in any portion. It is true that some sections are much more subject to loss than others, in fact that much of the loss is apt to be in a comparatively short distance. When such is the case it may be profitable for the company to take steps to lessen the amount of loss.

The loss of water from canals has been considered an incident necessary to the carriage of water. To a limited extent this is true, but where the loss is more than moderate, it may be considered as due to defective conditions, and generally can be lessened. The loss from the canals is a pure evil. It lessens the amount of water available for use and in so much lessens the productive power of the land under the canal. In some cases it may be sufficient to cause the damage or loss of crops. More than that, the seepage is undesirable to the lands below the canal. In most cases it is a positive injury, leading to the water-logging of tracts of land, and frequently results in troublesome claims for damage against the canal company.

METHOD OF EXPRESSING THE LOSS.

For the present I prefer to express the loss as the depth

over the surface of the canal, lost in one day, rather than in per cent. of the water in the canal. The losses from different canals are then more easily compared, and cases of unreasonable loss sooner recognized. In ditch management the tendency is to express the loss in per cent. in which case the loss suggests nothing as to the economy of water. To say, without other information, that a canal loses 25 per cent., gives no indication whether the carriage is economical or not. In a long canal the managers could congratulate themselves that it is no more; in a short canal it might be excessive and should set the officers to determining the location of the losses and to seek a remedy.

For those unaccustomed to this form of calculation, it is convenient to remember that the amount of water given by one cubic foot per second in 24 hours is enough to cover two acres one foot in depth (correct within less than 1 per cent.), and hence a daily loss of two feet over an acre would require the constant flow of one cubic foot per second to make good. The deeper the water in the canal the more rapid is the leakage, but with our ignorance of the exact relation we neglect the depth and consider only the surface of the canal. In the table full data is given and if the connection is subsequently determined, the data should be sufficient for the later investigations. It would doubtless be better to consider the wetted area of the canal rather than the width as a factor. As the canals are shallow and broad it matters little whether the surface area of the canal or the wetted area is used.

EVAPORATION RELATIVELY SMALL.

In considering the losses from canals, it is common to consider the loss from seepage and evaporation together. In most cases the evaporation is small in comparison with the loss from seepage. In ten years record of an evaporation tank freely exposed to the sun and wind, at the State Agricultural College, Fort Collins, Colorado, the annual evaporation has averaged but 41 inches.*

The temperature of the water surface in the tank is, however, lower than in many of the canals. As evaporation increases with the temperature of the water, the evaporation from some canals would be correspondingly

*Annual reports Colo. Agricultural Experiment Station, 1889 and 1890. Monthly evaporation given in full, table 4, p 18, bulletin 45, on Losses from Reservoirs.

greater. Nevertheless, only on specially favorable days can the evaporation from a canal surface amount to as much as one-half inch for the twenty-four hours. But the loss from seepage is rarely less than one foot and more often twice that in the same time, hence the evaporation is relatively small and may be left out of consideration in this connection without affecting our conclusions.

CANAL SEEPAGE IN THE CACHE A LA POUDRE VALLEY.

The Pleasant Valley and Lake Canal is an old canal taking water from the south side of the Cache a la Poudre river near the canon. It was originally built to supply lands in Pleasant valley, a glade of several hundred acres formed by the faulting and erosion of the rocks, principally the red sandstone, between the Dakota sandstones and the primitive rocks. The general course of the river is to the southeast; the canal sweeps to the south in a long curve, mounting the first and second benches and skirting at places the bluffs which form the edge of these benches. The ridge of Dakota sandstone confining the river between cliffs on either side, forces the canal back to the river, and its course almost overhangs the bed of the river. Through this ridge the canal is through and over the rock on a steep grade with some tunnels. The bank is often rockwork, with some soil. After passing this ridge the canal bends abruptly south, leaving the river at a large angle, and skirts the foot of the hog-backs formed of the ridge of resisting Dakota sandstone. It is thus the highest ditch on the south side of the river and like such ditches, is known locally as the "Highline." There is no irrigation of any extent above the canal. In several places a few acres are watered from reservoirs filled from small mountain streams. There can be no seepage into the canal except as furnished by the natural rains. The drainage of about 35 square miles is cut by the canal, but except in or after storms there are no surface streams. There are several small streams above the line of the ditch, but all disappear before reaching the line of the canal. Plum thickets show that spring waters appear near the surface in many places. The observers passed on foot along the bank of the ditch and thus could not miss any of the lateral headgates.

The conditions were favorable for loss by seepage. Much of the soil is of coarse gravel and sand, and the canal skirts the edge of the benches, across sandstone ridges with

the strata exposed and with a decided dip offering an easy course for descending waters.

The measurement showed a loss in 7 miles of over 15 cu. ft. per second; or, starting from the river with 22.09 cu. ft. a little over 2 cubic feet being withdrawn by lateral ditches, there were left but 4.54 cu. ft. or there was a loss of a little over 15 cu. ft. per second.

In the portion outside of the foothills occasional gains were found. In most cases the gains were found to be associated with drainage areas of some extent. The soil is largely disintegrated granite, coarse and porous, and absorbs rain very readily.

TABLE I a.

PLEASANT VALLEY AND LAKE CANAL.

Measurements made by R. E. Trimble and J. C. Mulder.

No. of Measurement.	Date and Hour.	Place of Measurement.	Amount.	Outtake.	Gain or Loss.	Dist. in Miles.	Notes.
	1897—						
1	Oct. 23, 9:20-' :50 a. m.	Canal near headgate	22.09				
	" 10:20 a. m.	Lateral		0.16			Gravelly and sandy; near river.
2	"	Canal (near Capt. Post's upper place)	17.23		-4.70	1.30	
	" -- 11:40 a. m.	4 Laterals		.69			
3	" 11:50-12 m.	Canal (point of bluff below school house)	10.64		-5.90	1.31	" " "
	"	6 Laterals		.02			
4	" 1:20-1:55 p. m.	Canal at road crossing	7.85		-2.77	2.39	West of Bellevue, clayey sand.
		10 Laterals		1.51			
5	" 3:10 p. m.	Canal (near C, E. Pennock's)	7.17		+0.83	1.45	Crosses several lines of drainage.
		Lateral		0			
6	" 3:55-4:00 p. m.	Canal (50 ft. below 1st tunnel)	6.29		-0.88	.82	Stratified slope; rocks inclining.
		Lateral		0			
7	" 4:30-4:35 p. m.	Canal (200 yds. above 2nd tunnel)	5.65		-0.64	.72	" " "
8	" 4:55-5:00 p. m.	Canal (at end of rock work on Bingham hill)	6.41		+0.76	.50	Crosses some of the glades of ridge.
		Lateral		0			
9	" 5:20-5:30 p. m.	Canal (near Claymore lake)	4 54		-1.87	.30	Along outer side ridge near junct'n of earth and rock.
9	30, 8:30-8:40 a. m.	At same place	17.98				
	"	2 Laterals		Trace			
10	" 9:20-9:30 a. m.	Canal (west of Michaud's)	19.07		+1 09	1.04	In excavation.
	" —	7 Laterals		1.19			
11	" 10:55-11:10 a.m.	Canal (west of Prendergast's)	16 53		-1.35	2.50	Crosses ridge of sandstone.
	" —	2 Latera s		1.16			
12	" 11:40-11:55 a,m.	Canal (west of cemetery)	13.57		-1.80	1.41	Along side hil', moderate slope.
	" --	2 Laterals		0.15			
13	" 1:15-1:25 p. m.	'anal (west of Loomis' farm)	13.42		0	1.94	Some seepage showing below ditch.
	" --	5 Laterals		6.19			
14	" 2:35 2:45 p. m.	Canal (west of B. B. Harris' farm)	11.73		+4.50	2.55	Some land irrigated above ditch from Dixon canon.
	" --	3 Laterals		0.16			
15	" 3:45-3:55 p. m.	Canal (west of Rugh Farm)	13 02		+1.45	1.75	Crosses some lines of drainage.
	" --	11 Laterals		2.82			
16	" 5:25-5:30 p. m.	Canal (west of Cun ninghams)	9.95		-0.25	2.64	More gravelly, some irrigated land above ditch from Spring canon.

Measurements by R. E. Trimble and J. D. Stannard.

12	1898— April 23, 8:55 a. m.	Canal west of Cemetery	17.26				10:10 a. m. at starting point, no change noticed.
		2 Laterals		1.25			
	" 9:45-9:57 a. m.	Canal near west end of bend about ½ mile.	17.56		+1.55		
13	" 10:25-10:38 a. m.	Canal west of Loomis' farm	17.97		+0.41	1.94	At 2:00 p. m. the water had fallen ⅝ in.
		8 Laterals		6 62			
14	" 12:02-12:12	Canal west of B. B Harris' farm	12 67		+1.32	2.55	Water fallen ½ inch since noon.
	" 2:30-2:41 p. m.	At same place	11.69				
		6 Laterals		0.61			Water had fallen 2 inches by 4:25 p.m.
15	" 3:40-3:50 p. m.	Canal west of Rugh farm	8.53		-2.55	1.75	Water had fallen ½ inch by 6:10 p. m.
		10 Laterals		3.31			
16	" 5:38-5:45 p. m.	Canal west of Cunningham's	5.91		+0.69	2.64	

TABLE I b.

PLEASANT VALLEY AND LAKE CANAL.

Place of Measurement.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth in Feet.	Greatest Depth in Feet.	Surface Width. Feet.	Gain or Loss. Sec. Feet.	Distance in Miles.	Equivalent depth of Loss in ft.
1	42°.7	21.23	1.34	1.72	15.9	....	0	....
2	43°.9	18.74	.90	1.26	18.9	-4.70	1.30	-4.7
3	44°.5	7.20	.64	0.81	11.2	-5.90	1.31	-5.1
4	48°	7 26	.63	0.87	11.5	-2.77	2.39	-1.7
5	48°	4.89	.54	0.75	9.0	+0.60	1.45	+0.7
6	48°	3.93	.44	0.65	8.8	-0.71	.82	-1.6
7	48°	3.68	.50	0.72	7.4	-0 64	.72	-0.4
8	48°	4.90	.65	0.97	7.5	+0.76	.50	+1.7
9	47°.5	12.63	1.09	1.59	11.6	-1.87	.30	-3.2
9	39°	18.40	1 36	2.07	13.5	....	0	....
10	39°.5	13.71	.64	0 79	21.5	+1.09	1.04	+1.0
11	41°	14.40	1.00	1.27	14.3	-1.35	2.50	-0 5
12	42°	12.56	.70	1.12	16.3	-1.80	1.41	-1.4
13	44°	13.73	.84	1.10	16.3	0	1.94	0
14	44°.2	12.40	.84	1.42	14.8	+4.50	2.55	+1.9
15	44°.5	11.01	.77	1.02	14.4	+1.45	1.75	+0.9
16	....	9.98	1.00	1.45	10.0	-0.25	2.64	-0.1
12	50°	15.45	1.13	1.39	13.7	0	....	....
13	51°.8	13.60	1.07	1.35	12.7	+1.55	....	....
13	53°.0	13.92	.97	1.26	14.4	+0.41	1.94	+1.3
14	55°.0	12.24	.84	1.25	14.6	+1.32	2.55	+0.6
14	55°.0	11.99	.79	1.34	15.1	....	....	....
15	55°.8	9.11	.67	0.88	13.5	-2.55	1 75	-2.7
16	55°.0	5.90	.62	1.01	9.5	+0.69	2.64	+0.4

SEEPAGE FROM CANALS IN THE SAN LUIS VALLEY.

Measurements were made to determine the loss by seepage and absorption on a number of canals and on laterals, approaching canals in size, in the San Luis valley, and the measurements are given in the following tables. These include measurements of the losses on the Empire canal, on the Blackmore or Fisk Ditch, on the Prairie Ditch, on a

branch of the Rio Grande canal, known as the North Farm lateral or ditch, and on other laterals of the company known as the 1F and 1C laterals.

The conditions in the San Luis valley are somewhat different from those in most places of the state, but the conditions causing the loss or gain by canals are necessarily the same.

The San Luis valley is one of great extent—nearly the size of Connecticut. In Geological times it was the bed of a lake. Its surface is of very uniform and moderate slope, so that canals often pass for long distances in straight lines. The Prairie Ditch, for example extends nearly twenty-six miles on a straight line without turn or bend. The fall of the country is moderate, though large for canal purposes. It decreases from about fourteen feet per mile near the rim east and west, to half as much as the center of the valley is reached. A map of the valley showing these contour lines has been prepared and will be published in connection with a bulletin giving further results of investigations in the valley.

A large part of the valley is irrigated by sub-irrigation which consists in filling the sub-soil by water from the canals and laterals. The slope of the land is so uniform and gentle that the water does not find low places in which to appear in the form of seepage as in an undulating region.

The general process of irrigation in these regions is to run water into the laterals and allow it to soak away, and by so doing fill the sub-soil until the water is at a moderate distance from the surface, about eighteen inches being desired during the growing period of the grain crops. The soil of the valley is very deep, but is everywhere underlaid with coarse gravel which becomes finer as the distance from the mountains increases. Most of the ditches are excavated into this gravel.

The irrigated region includes most of the valley east of what is known as the "Gun-barrel road"—which extends directly north from Monte Vista—and the tract in which sub-irrigation shows, includes a portion of this region. In places irrigation extends west of the road. It may be expected that as long as the surface of the underground water is below the bottom of the canal there will be loss of water by seepage. Where the ground water rises above the bottom the canal may then act as a drain and carry away a portion of the ground water, and the canal is thus found to increase in volume by seepage.

Circumstances prevented making as extensive measure-

ments of canals as desired, but a distance of some forty miles has been measured, which is sufficient to reveal the extent of the losses and some of the conditions.

The Empire canal is one of the largest canals taken from the Rio Grande river. It heads on the south side some miles east of Monte Vista. It is cut rather deeply in the plain. In the first five miles there is found a gain of six cubic feet per second.

The Blackmore ditch is a small ditch on the north side of the river, heading nearly opposite the town of Monte Vista and extending east. It starts above the region that is showing sub-irrigation and for a portion of its length its channel is a little above the plain. It was found to lose nearly four cubic feet per second in two miles.

The Prairie ditch was measured for some miles from its headgate directly east. The change in volume seems to be irregular, there being a gain of 1.42 feet in three miles, passing across the river bottom, then a loss of 1.80 feet in one and one-half miles through a gravelly soil; then as it strikes the region that is more or less sub-irrigated, a gain of a little over two feet in the first two miles and a gain of a little over a foot in the next two miles. The last mile measured showed a loss of nearly two cubic feet per second.

The North Farm lateral is a branch of the Rio Grande canal. The Rio Grande canal takes water from the Rio Grande river near Del Norte and with a northeast course runs almost at right angles to the river to Saguache, forty-five miles northeast. The North Farm lateral passes nearly parallel to the river. Its course is through the gravelly soil and the excavation extends into the boulder gravel for most of the length measured. Mile posts are placed along the ditches belonging to the company, so that distances could conveniently be told. The first measurement was made at the second mile post from the main canal and then at each subsequent mile post along the line of the lateral. Two measurements were made at different times, on July 6th and August 3rd. At the first date the amount of water in the lateral was nearly twice as great as at the last date, and the loss of water was found to be about twice as much. The measurement was carried on until the canal reached the border of the sub-irrigated region.

Laterals 1 F and 1 C, which were measured, are branches of the same system.

A measurement was made on the loss of water from the Blackmore ditch early in May, in a stretch east of the "Gun-barrel road" and included in the measurement otherwise re-

ported. The amount of water in the lateral was measured by floats at two points nearly one-half mile apart. The discharges were found to be 2.85 and 2.43 cu. ft. per second in two places, or a loss of .93 cu. ft. per sec. per mile of ditch, or equivalent to a depth of 3.72 feet over the surface of the ditch. If the gravel consists of one-third voids this would be equivalent to a velocity of 12 feet per day through the soil.

TABLE II a.

LATERAL 1C RIO GRANDE CANAL SYSTEM.

Measurement by R. E. Trimble.

Date and Hour.	Place of Measurement.	Amount Measured Sec. Feet.	Outtake. Sec. Feet.	Gain or Loss. Sec. Feet.	Distance in Miles.
August 2, 4:30 p. m.	3½ miles	18.79	....	....	....
" 4:00 p. m.	4th mile post	21.17	....	+2.38	0.5
" 3:45 p. m.	5th mile post	17.36	....	-3.51	1.
" 3:20 p. m.	6th mile post	15.06	....	-2.60	1.
" ——	Lateral 100 yards below 6-m	....	7.56	....	....
" ——	Lateral ½ mile below 6-m.	....	0	....	....
" 2:30-2:45 p. m.	At 7th mile post	7.30	....	-0.20	1.
PRAIRIE CANAL.					
1897—					
July 13, 3:20 p. m.	Ne r headgate	36.41	....	....	....
" "	McDonald lateral	....	2.25	....	....
" "	Small ditch	....	.08	....	....
" " 4:20 p. m.	1½ mi. west Gunbarrel road	35.50	....	+1.42	3.5
" "	Lateral	....	1.79	....	....
" "	Lateral	....	0.13	....	....
" "	At Gunbarrel road	31.91	....	-1.80	1.5
" 14, 8:20 a. m.	At Gunbarrel road	29.25	....	....	....
" " 9:10 a. m.	North of North Farm	31.39	....	+2 14	2.
" "	3 Laterals	....	2.81	....	....
" " 10:25 a. m.	4 miles east.	29.62	....	+1.04	2.
" " 11:00 a. m.	5 miles east.	27.80	....	-1.80	1.

TABLE II b.

LATERAL 1C RIO GRANDE CANAL SYSTEM.

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth. Feet.	Greatest Depth, Feet.	Surface Width, Feet.	Gain or Loss. Sec. Ft.	Distance in Miles.	Corresponding Depth of Loss.
Aug. 2, 4:30 p. m.	70° 8	10.48	.65	0.89	16.	....	....	....
" 4:00 p. m.	72°.3	9.38	.59	0.90	16.	+2.38	0.5	+4.95
" 3:45 p. m.	75°.4	6.94	.73	1.10	9.5	-3 51	1.0	-2.88
" 3:20 p. m.	78°.0	8.96	.75	1.04	12.	-2.60	1.0	-3.60
" 2:30 p. m.	81°.0	10.04	.69	1.32	11.3	+0.35	1.0	+.48
PRAIRIE CANAL.								
July 13, 3:20 p. m.	....	38 30	1.38	1.70	27.7	....	0	....
" " 4:20 p. m.	....	17 42	.67	1.40	26.	+1 42	3½	+.85
" " 5:15 p. m.	....	19.60	.98	1.28	20.	-1.80	1½	-.86
" 14, 8:20 a. m.	62°	18.32	.92	1.20	20.	....	....	....
" " 9:10 a. m.	65°	14.20	.42	0.80	23	+2.14	2	+.79
" " 10:25 a. m.	67°.5	12.30	.57	0.65	21.6	+1.04	2	+.38
" " 11:00 a. m.	71°	15.12	.57	0.65	26.	-1.80	1	-1.24

TABLE III a.

NORTH FARM LATERAL.

First and Second Measurements.

Date and Hour.	Am't.	Out-take.	Gain or Loss.	Distance in Miles	Place of Measurement.	Date and Hour.	Amt	Out-take	Gain or Loss.
July 6, 1897.						Aug. 3, 1897			
11:00 a. m.	199.50				150 feet above mile post 2*	9:45 a. m.	90.50		
11:30 a. m.		85.085			North branch	11:00 a. m.		40.75	
11:40 a. m.	123.81		+9.41	2.	South " near 4th mile post		53.29		+3.52
1:10 p. m.	124.45	0	+0.63	1.	5th mile post	11:30 a. m.	52.14		-1.15
2:15 p. m.	117.55	0	- 6.90	1.	6th mile post	12:50 p. m.	49.33		-2.81
2:45-3:00 p.m.	103.32	0	-14.23	1.	7th mile post	1:30 p. m.	44.92		-4.41
		23.00			Lateral	1:50 p. m.		12.76	
3:40 p. m	89.38		+9.06	1.	8th mile post	2:10 p. m.	5.96		+3.80
4:00 p. m	78.50		-10.88	1.	9th mile post	2:35 p. m.	34.10		-1.86
		29.33			Lateral about ¼ mile below			7.67	
		2.11			" " ⅜ " "			.01	
		4.72			" " ½ " "			0.60	
		10.10			"			1.70	
5:00 p. m	32.54		+0.30	1.	10th mile post	3:35 p. m.	22.92		-1.14
		0 43			Lateral 200 yards below			.39	
		1.51			" " " "			.01	
		.22						.02	
5:30 p. m.	30.44		.06	1.	11th mile post	4:20 p. m.	20.89	.40	-1.21
					* Bottom of boulder gravel, size of man's fist.				
					Gage height .13				

TABLE III b.

NORTH FARM LATERAL.

First Measurement.

(By R. E. Trimble and J. D. Stannard.)

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth in Feet.	Greatest Depth in Feet.	Surface Width in Feet.	Gain or Loss. Sec. Ft,	Distance in Miles.	Corresponding Depth of Loss.
July 6.—								
11:00 a. m.		69.16	1.47	2.00	47.			
11:40 a. m.	61°.5	34.55	1.19	1.65	29.	+9.41	2.	+2.04
1.10 p m.	65°	36.70	0.92	1.40	40.	+0.63	1.	+.3
2:15 p. m.		35.15	1.40	1.90	25.	- 6.90	1.	-3.0
2:45 p. m.		31.30	1.30	1.70	24.	-14.23	1.	-9.6
3:40 p. m.		23.15	0.93	1.20	25.	+9.06	1.	+6.1
4:00 p. m.	68°	25.02	1.32	1.85	19.	-10.88	1.	-8.1
5:00 p. m.		11.95	0.80	1.25	15.	+0.30	1.	+.3
5:30 p. m.		12.95	1.44	1.10	9.	+0.06	1.	+.08
Average			1.20		26.			
Total loss						-12.55		

Second Measurement — By R. E. Trimble.

Date and Hour.	Temp. of Water.	Area of Section. Sq. Feet.	Average Depth in Feet.	Greatest Depth in Feet.	Surface Width in Feet.	Gain or Loss. Sec. Ft,	Distance in Miles.	Corresponding Depth of Loss.
Aug. 3, 1897.—								
10:10 a. m.	62°.0	33.56	1.12	1.95	30.0			
11:00 a. m.	64°.0	20.64	0.94	1.85	22.0	+3.53	2	+.62
11:30 a. m.	65°.2	21.97	1.04	1.41	21.2	-1.15	1	-.88
12:56 p. m.	67°.3	22.54	0.88	1.26	23.0	-2.81	1	-2.1
1:30 p. m.	71°.0	20.23	0.91	1.75	22.2	-4.41	1	-3.2
2:00 p. m.	70°.2	14.68	0.67	0.89	22.0	+3.80	1	+2.85
2:35 p. m.	71°.8	15.73	0.94	1.28	16.7	-1.86	1	-1.6
3:20 p. m.	72°.3	9.36	0.67	1.03	14.0	-1.15	1	-1.2
4:20 p m.	72°.0	11.06	0.74	.95	15.0	-1.23	1	-1.4
Average		18.86	0.88		20.7			
Total loss						-5.28	9	

TABLE IV a.

EMPIRE CANAL.

Measurement by R. E Trimble and R. D. Blakey.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
1897— June 11, 2:40 p. m	At head	124.99			
	Davis lateral		1.90		
	Davis No. 2		0		
	Metzger No. 1		0		
	Metzger No. 2		0		
	Metzger No. 3		3.12		
June 11, 4:35 p. m	Above Loveland lateral	135.97		+16.00	5

BLACKMORE DITCH.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
June 17, 2:40 p. m	At bridge	11.54			
June 17, — p. m	At lateral		1.16		
June 17, 3:30 p. m	South of North Farm	6.78		-3.60	2.03 m
May	At bridge	2.85			½ "
"	½ mile east by floats	2.43		-.42	

LATERAL 1 F.

Date and Hour.	Place of Measurement.	Amount	Outtake	Loss or Gain.	Distance.
Aug. 4, 10:30 a. m	At head	12.93			
10:10 a. m	2½ miles from G. B. road	11.29		-1.64	2½ m
	Lateral		1.67		
	"		0.37		
	"		0.39		
9:25 a. m	1 mile	8.82		-.04	1½ m
	Lateral		1.70		
	"		0.51		
	"		.01		
9:00 a. m	Near Gunbarrel road	7.84		1.24	1 m.

TABLE IV b.

EMPIRE CANAL.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
1897 — June 11, 2:40 p m		79.6	1.82	2.41	44		
4:35 p m		70.2	1.40	1.70	50	+16.00	+1.1

BLACKMORE DITCH.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
June 17, 2:40 p. m		10.35	.94	1.21	11.0		
3:30 p. m		4.61	.62	.84	7.4	-3.60	-7.2

LATERAL 1 F, RIO GRANDE CANAL SYSTEM.

Date and Hour.	Temp.	Area.	Average Depth.	Maximum Depth.	Breadth.	Gain or Loss.	Corresponding Depth in Feet.
Aug. 4, 10:30 a. m	67°.2	6.24	0.48	0.80	13.		
10:10 a. m	67°	6.30	0.63	0.86	10.	-1.64	-.95
9:25 a. m	65°	5.93	0.66	0.99	9.	-.04	-.05
9:00 a. m	63°.2	4.20	0.54	0.76	7.8	+1.24	+2.4

OTHER CASES.

The loss on a section of the Fort Morgan canal given in table V, is the loss in a section between the headgate and Bijou creek, some ten miles down the line of the canal, and about four miles from Fort Morgan.

The canal is on the south slope of the Platte valley and for much of the way is a loose sandy soil. It is in partial excavation and with an embankment on the lower or northern side.

The loss in this canal amounted to twenty cubic feet per second in 1895 in a distance of 7.4 miles In 1896 the upper measurement was made nearly two miles further up the canal, and the lower measurement at the same place as in 1895. The loss amounted to 23.11 cu. ft. per second.

These measures are referred to later, as they afford a basis for seeing the effect of slightly silting the canal.

TABLE V.

FORT MORGAN CANAL.

Date and Hour.	Temp. of Water.	Area of Section Sq. Ft.	Aver'ge Depth in feet.	Greatest Depth in feet.	Surface Width in feet.	Gain or loss. Sec. Ft.	Distance in Miles.	Corresponding Depth in Feet.	Notes.
1895— Oct. 25, 7:30-8:25 a.m.	41°	108.9	2.42	3.20	45	......	......	......	Opposite Shaffer's Ford.
" " 11:00 a. m.	44°	69.	1.82	2.34	38	-20.08	7.4	-1.1	Head Bijou flume. 10,100 ft. new channel; 400 ft. is flume. No leak from flume.
" " 12:30 a. m.	....	110.	2.55	3.65	34	-11.48	2	-2.6	
FORT MORGAN CANAL.									
1896— Oct. 23, 9:15-10 a. m.	48°	67.60	2.01	2.05	33.7	......	0	......	At rating flume.
" " 3:05-3:50 p.m.	....	110.20	2.75	3.40	40	......	......	......	Opposite Shaffer's Ford.
" " 3:30-4:00 p.m.	49°	95.6	2.45	3.50	39	-23.11	9.3	-1.0	Head of old flume.
" " 4:20-5:00 p.m.	....	102.3	2.38	3.50	43	- 5.70	2	-1.1	At lower end old flume, 10,100 feet used one year. As ditch changed slightly during night measure at Shaffer's Ford is not used.
HOOVER DITCH.									
1895— Oct. 22, 7:30 a. m.	....	5.45	.65	.85	8.4	......	......	......	
....	....	10.2	1.4	1.80	7.4	-0.15	¼	-1.2	Fine sand of Platte river bed.
GREELEY NO. 3 CANAL.									
1895— Oct. 16.	....	17.49	1.03	1.56	17	......	......	......	
....	51°	21.03	1.45	1.65	14.50	5.06	760 ft.	-55.0	Above and below gully in west part of City of Greeley. Instance referred to in bulletin 33 pp. 49-50.

In the case of the ditch of the City of Fort Collins, carrying water from the Cache a la Poudre river to the city water works, a distance of 4100 feet, the ditch lost 4.34 cu. ft. per sec., equivalent to a loss of 5.7 feet in depth per day. The ditch runs through the bottoms and along the side of a hill rising some 20 feet above the bottom lands below. Immediately above the city ditch, as near the slope as the embankment will permit, is another canal, the New Mercer ditch, which, at the time of measurement, was dry. The Pleasant Valley and Lake canal is still higher, over one-half mile distant, but the seepage from this canal is carried in another direction by the local configuration of the country.

The loss from canals has not been extensively studied and there seem few instances available where the results of measurements are given. In bulletin 33 several cases are referred to.

MISCELLANEOUS OBSERVATIONS.

The following cases are derived from other observers:

On the Muzza canal, Italy, the loss is equivalent to a depth of 1.7 feet in 24 hours.* The canal is the first built near Milan solely for irrigation purposes, the other large canals including navigation as an object in their construction. The Muzza has a heavy fall, giving the current too large velocity for navigation. The canal carries several thousand cubic feet of water per second, and under conditions as seen by the writer in 1892, that would seem favorable to percolation, so that the reported loss seems small.

The Naviglio Grande loses 10 inches daily in depth. This canal was built over 700 years ago, about the same time as the Muzza. The canal Martesana loses 1.5 feet daily.*

The Centreville and Kingsburg canals, California, in a stretch of six miles lost a depth of 6 feet per day. The King river and Fresno canal lost in different portions depths of 1.5 feet, 1.7 and .6 feet.

Portions of the Fresno canal lost depths of 2.8 feet, .25 ft. and .4 ft. in depth, and some laterals from 1.2 to 6.4 feet.†

In the case of several canals in Kern county, California, the loss was found to be from .39 to 2.6 feet in depth in 24 hours, ranging from 1 to 2 feet in sandy soils and averaging 1.6 feet; in sandy loam and firm, compact alluvial soil, from .39 to 1.30 feet averaging .87 feet in depth.‡

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* Baird Smith, Italian Irrigation.

† On authority of C. E. Grunsky, C. E. of San Francisco, given in Bulletin 33

‡ Report Cal. State Engineer, 1880, App. B. by J. D Schuyler p 92 The results are changed to depths by the writer.

Mr. J. Keelhoff made some experiments on the absorption of small ditches.*

From the facts given by him, we find that the loss in the sandy soil of the Campine from irrigation ditches, 10 inches wide with water 11 inches deep, was over 10 feet in depth in 24 hours; but when the depth of water in the ditch was but two inches, the loss was reduced to six feet per day. In the distributing laterals, 10 inches deep and two feet wide, the loss was over four feet in depth per day. In the principal lateral, with water 2 feet deep and 8 feet wide, the loss was over 2 feet per day. One reason for less loss in the last case, though the water was deeper, is that the bottom remains undisturbed from year to year. At the time of the test the silt had not been removed for four years. The other ditches were cleaned annually, thus giving a raw surface for the water to pass through.

Geo. W. Rafter, C. E. in a report on the water supply of the Western division of the Erie canal,† refers to a number of determinations of the losses from seepage and evaporation on stretches of that canal.

On a section of 18 miles near Schenectady through an alluvial soil containing a large proportion of vegetable matter, and leaky in places, the loss as measured by J. B. Jervis in 1824, was 2 cu. ft. per second per mile. The canal was 28 feet wide on bottom, 40 feet wide on top and 4 feet deep. This is equivalent to a loss in depth of 10 inches in 24 hours over the whole surface.

Mr. David S. Bates in 1823 concluded that a mile of new canal, such as the Erie then was near Brockport, would require 1⅔ cu. ft. per sec. per mile. This included evaporation. The dimensions of the canal are presumably the same as the above, in which case the loss would be equivalent to 8 inches in depth per day. On the Chenango canal in Aug. 1839, the amount was found to be 1.09 second feet per mile, corresponding to a depth of 6 inches in 24 hours.

On the Erie canal near Wayneport, in 1841, in a distance of 8 miles, when the soil was open and porous, the loss was 1.8 cu. ft. per second per mile; on the Clyde level, a length of 28 miles, with more retentive soil, the loss per mile was only .6 cubic feet per second. These correspond to depths of 9 inches and 3 inches per day respectively.

In comparing with the results found on irrigation canals, it should be remembered that the conditions on the

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* Traite Pratique de l'Irrigation des Prairies. 2d ed.

† Report of the State Engineer and Surveyor of N. Y., 1896.

Erie canal are more favorable to small losses than are those of irrigation canals. The Erie canal is in a more humid climate, with a rainfall about 2½ times as great as that of Colorado and this tends to keep the water table nearer the surface and thus lessen the percolation. More than that, the Erie canal in this stretch is almost level (3 ft. fall in 60 miles) and the slow movement of the water is favorable to silt deposition. The irrigation canals have falls ranging from 2 ft. upward per mile, and the beds are scoured by the running water.

Mr. Walter James, who has been for many years the engineer of the canals in Kern county, California, writes* that their experience shows that they deliver 70 per cent of the water turned in at the head of the canals at the lateral side gates, measurements sometimes being made from one to three miles from the main ditch at the lands where the water is used. There is one point on the Calloway canal where there is a loss of 75 cu. ft. per sec. in a distance of half a mile.†

The canals referred to by Mr. James are from 6 to 25 miles in length, and from two to three feet in depth. In their experience they find that an allowance of 2 per cent. per mile of main canal approximates fairly well to the loss to be counted upon.

On the Carpentras canal of Vaucluse in France, taking water from the Durance, the loss was found to be great, though the waters of the Durance are thick with mud ordinarily. The canal passes along the flank of calcareous slopes. The soil is generally thin. The banks were walled and the canal paved in many places. After these remedies, the loss is still considered to be about 30 per cent of the amount taken by the canal.‡

The canal carries 210 cu. ft. per second. The loss corresponds to a depth of 1.2 feet over the length of the canal, which is 40 miles.

The Marseilles canal in Southern France, which had cost $9,000,000 up to 1878, at first lost about 20 per cent., notwithstanding that the water supplying the canal is exceptionally muddy, so much so that it was necessary to build settling basins at considerable cost. The loss was reduced to 10 per cent. by works protecting the banks, made at a

*June 13, 1898.
†This is equivalent to a daily loss of 30 feet in depth.
‡Salvador, Hydraulique Agricole, (1898) 2:492.

cost of $400,000.* The loss under these favorable circumstances still amounts to about 5 inches in depth per day.

Where the Cavour canal crossed the valley of the Dora river it was confined by artificial banks and the losses at first were found to be enormous, being not less than 210 cu. ft. per sec. in a distance of but little over one mile.† This corresponds to a depth of 20 feet per day over the entire width of the canal.

This great loss was remedied by using sand in the bottom, using water made muddy with clay, and lime water, and after repeating the application several times the losses were found to be much less. After continuing the application for a couple of months, keeping the water stagnant to allow the material to settle, the losses were very much reduced.

CONTINUOUS RECORDS.

For two years a self recording nilometer was maintained on a ditch four miles long, belonging to the North Poudre Land and Canal company. The lateral had no outlets for that distance. Weirs were placed at the upper end near the reservoir from which the water was drawn, and also near the lower end about four miles from the reservoir. No water was used at intermediate places. The record was made to ascertain the loss there might be from seepage and evaporation during the time. The lateral is built in a soil mostly of clay, which does not wash unless the velocity is considerable. The seepage was not expected to be great because of the character of the soil. Two weirs were put in place and instruments were put in place at the side of the ditch, with floats so arranged that as the water rose or fell a pen rose or fell on the paper correspondingly. The clockworks would run a week without rewinding. At the end of each week the instruments were visited, the clock rewound, the papers changed, and check readings of the height of water over the weirs taken.

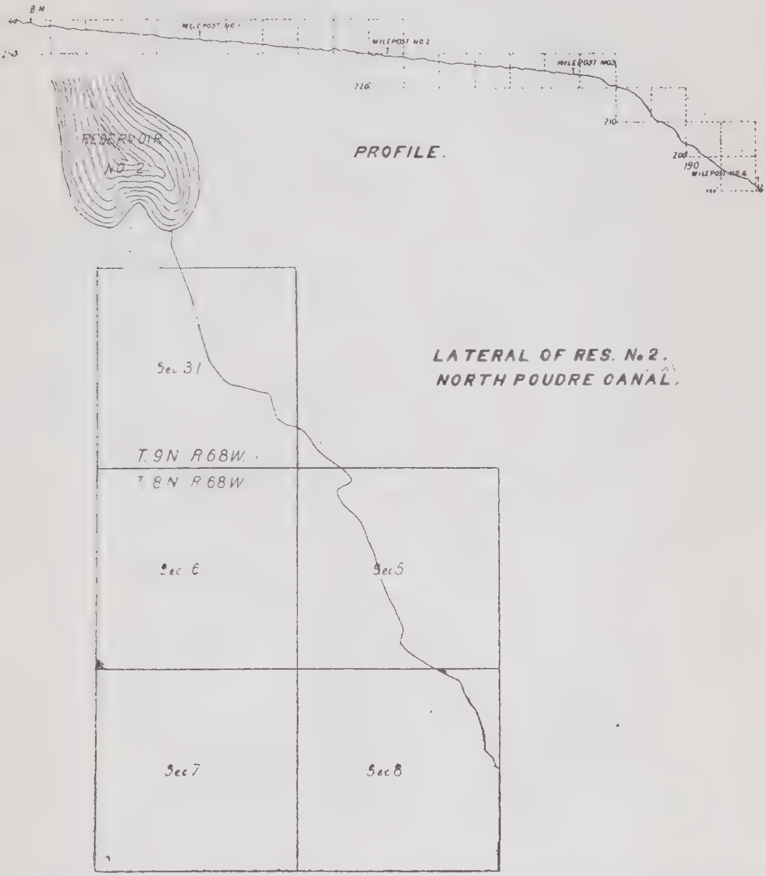
After the instruments were in service it was found that about ten acres of ground was supplied from the lateral above the lower weir. The cases when water was drawn for this tract are eliminated from the table, but the conditions were not entirely satisfactory, and, as the funds to meet the small expense of removing the weir above this lateral were not available for the department at that time, the measurement was dropped. A ditch in the southern part

* Salvador, Hydraulique Agricole. 2:42.

† Herrisson, Les Irrigations de la Vallee du Po. p. 77.

of the state, 40 miles in length without an outlet, has been put at our service and records are to be made on it, giving, it is hoped, information on a more extensive scale.

The line and profile of the canal is shown in the figure.



For the first mile the canal had a fall of 5.4 feet, in the second mile 4.8 feet, in the third mile 5.8 feet and in the last mile 34 feet. The reason for this rapid increase of grade is, that for the first three miles the ditch skirts the side of a divide, while a short distance after passing the third mile post it reaches the ridge of the divide and descends with the slope of the country which is quite abrupt.

The soil through which the canal runs may be termed a heavy clay. Where the water is rapid, as during the last mile, the sides of the channel become smooth with the

action of the water and comparatively little washing takes place. In the course of years, however, the washing is sufficient to deepen the channel several feet below the surrounding country. As the water comes from a reservoir, it is clear except for the turbidity due to a slight amount of organic matter. The water retains its clearness for the greater length of the canal, but at the lower end contains some sediment from the scour of the channel. The soil is probably underlaid with sand and gravel at a depth of 8 or 10 feet—true of most of the surrounding country—but no opportunity to test was afforded along this line.

For the first three miles the seepage would be to the west; for the remainder of the distance it might take place both to the right and left of the channel. Some seepage showed near the northeast corner of section 8 where an area of a few acres gave evidence of water-logging. Because of the sand carried by the rapid fall at the lower end, the space in front of the lower weir is filled with sediment. This increases the discharge by increasing the velocity of approach. Near the lower end of the canal a small lateral irrigating about 10 acres of land conveyed water to the north. When water was running in this lateral notes were taken and this time was not taken into account.

TABLE VI FROM CONTINUOUS RECORDS ON DITCH, 4 MILES LONG.

1893. June.	Av. Flow per Sec. over Weir.		Av. Loss per Sec. cu. ft.	Loss per Cent	Maximum Flow over Weir.		Minimum Flow Over Weir.		Air Temperature at College.		Av. Rel. Humid'y at College.	Wind at College, Miles per Day.	NOTES ON WEATHER.
	Upper.	Lower.			Upper.	Lower.	Upper.	Lower.	Average.	Max.			
14	4.42	4.31	0.11	2.4	4.72	4.57	4.18	4.16	69.0	80.0	47.0	165	Sunshine to 3 p. m.
15	4.04	3.87	.17	4.2	4.72	4.17	4.18	4.18	62.0	81.8	56.5	138	Sunshine all day.
16	4.51	3.79	.83	18.0	4.72	4.10	4.51	3.74	64.5	85.2	47.9	155	Sunshine nearly all day.
17	6.65	5.21	1.44	21.6	8.95	7.18	4.43	3.74	68.7	90.9	53.9	163	Sunshine all day.
18	8.77	6.91	1.86	21.2	8.95	7.18	8.52	6.77	71.0	93.7	45.1	167	" " "
19	8.12	6.48	1.64	20.2	8.52	6.77	7.68	6.37	72.0	94.0	44.9	158	" " "
20	6.20	6.02	.18	2.8½	7.67	6.37	3.47	5.69	68.8	92.3	49.3	285	" " "
21	7.35	5.47	1.88	25.6	7.43	6.13	5.83	4.79	74.7	87.4	28.9	236	Sunshine nearly all day.
22	5.12	4.25	.86	16.9	5.83	4.79	4.57	3.81	67.6	90.8	50.6	164	" all day.
23	4.42	3.67	.75	16.9	4.57	4.36	4.17	3.40	74.3	91.1	19.3	257	" nearly all day.
24	6.26	4.80	1.46	23.4	7.76	5.57	4.57	4.36	64.1	80.2	48.0	212	" most of day.
25	5.92	4.94	.98	16.6	6.62	5.57	5.23	4.29	68.0	88.3	58.9	171	" all day.
26	3.78	3.32	.46	12.2	5.23	4.29	1.90	1.62	67.5	84.7	54.4	147	Rather cloudy.
27	1.82	0.96	.86	47.1	1.90	1.62	1.73	.84	67.7	88.1	40.6	144	Sunshine most of day.
28	1.81	.47	1.34	74.0	1.73	.82	1.47	.22	70.1	92.0	49.1	148	" " "
29	1.11	.41	.70	63.1	1.47	.70	.12	.28	65.2	73.6	71.8	192	Rather cloudy.
30	.63	51	.12	19.2	1.13	.58	.25	.31	65.7	83.9	49.8	190	Sunshine nearly all day.
1894.													
June.													
22	3.73	3.47	.26	6.9	3.83	3.62	3.72	3.32	65.9	81.9	65.2	143	Rain T. cloudy after 11 a. m.
23	3.72	3.30	.42	11.3½	3.72	3.42	3.72	3.13	64.6	80.7	53.7	163	" T. partly cloudy after 9 a. m.
24	3.72	3.24	.48	12.9½	3.72	3.22	3.72	3.06	63.2	77.4	58.0	188	" .10 in partly cloudy.
25	2.10	2.06	.04	2.0	3.72	3.13	....	....	63.2	80.4	58.6	138	" T. partly cloudy.
July.													
16	2.55	0.77	1.78	69.9	4.79	3.32	2.99	2.99	71.5	90.0	58.5	126	Partly cloudy in p. m.
17	5.68	4.04	1.64	28.8	7.14	5.55	4.14	2.99	74.0	89.0	59.7	128	Partly cloudy all day.
18	6.44	5.55	.89	13.7	7.02	5.55	6.17	5.55	68.3	79.7	75.1	121	Rain .15 in., cloudy.
19	6.15	5.55	.60	9.8	6.29	5.55	5.73	5.55	68.6	77.6	74.3	120	Cloudy p. m.
20	6.12	5.72	.40	6.5	7.39	6.29	5.73	5.55	66.7	82.7	69.4	131	Partly cloudy in p. m.
21	6.18	5.99	.18	3.2	6.53	6.29	5.64	5.55	67.8	87.8	48.8	160	Rain T. partly cloudy in p. m.
22	2.49	2.77	Gain	Gain	6.29	5.55	0	0	67.6	89.2	54.8	159	Gain from saturated banks.
30	2.19	1.49	.70	32.3	4.90	3.52	4.46	3.42	69.5	90.4	52.5	166	Partly cloudy p. m.
31	4.33	3.52	.80	18.7	4.46	3.52	4.25	3.52	71.2	59.2	61.4	194	Rain .19 in. p. m., partly cloudy.
Aug. 1	2.85	2.73	.12	4.5	4.25	3.52	2.02	1.85	68.0	82.2	58.5	205	Rain T. cloudy.
Ave.	**4.49**	**3,73**	**.80**	**20 9**	....	....	....	....	**68.1**	....	**53.5**	**169.**	....

The average loss amounts to .80 cu. ft. per sec. As the amount turned into the ditch averaged 4.49 cu. ft. per sec. the loss amounted to 18 per cent. on this basis, or 22 per cent. by taking the average of the losses by days.

As the surface of the water of the canal was about three acres in area, this amount of loss corresponds to a depth of slightly over 6 inches per day.

The variations in the loss on different days is noticeable. A part of the difference is due to the fact that a fluctuation in the amount of water in the canal does not affect the lower weir until a couple of hours after the upper weir has been affected, and as the civil day was used with both weirs, some discrepancy is due to this fact. The days when the changes were noticeable were excluded from the table though the effect is not thereby entirely elminated from the individual day's record.

The days when water was used through the small lateral above the lower weir could easily be detected by comparison of the records at the two weirs, and are likewise excluded from the table.

Showers affected the record to some extent in 1894, and while the amount of rain entering the canal is unknown, there is reason to suppose that its effect caused the apparent losses to be less than in 1893, whose record for the time reported was free from such disturbance.

RECAPITULATION OF CASES OF LOSS.

	Depth.
Pleasant Valley and Lake Canal: Loss of 11.46 sec.-ft. in 23 miles, after being increased by over 8 ft. gain.	
Average depth of loss, with low head.......	0.66 ft.
Excluding gains, loss of over...............	1.00 "
At places, over............................	5.00 "
North Farm Lateral: Lost 12 5 ft. in 9 miles, with head of 200 sec. ft.	
Average depth of loss.....................	0.80 "
With head of 90 ft. lost 5.28 sec. ft. or depth.	0.43 "
Fort Morgan Canal.........................	1 to 2.60 "
Hoover Ditch	1.00 "
Greeley No. 3, special case	30.00 "
" " " July 20, 1898	18.00 "
North Poudre Lateral................6 to 1.00	0.80 "
Muzza Canal, Italy.........................	1.70 "
Naviglio Grande...........................	0.80 "
Martesana	1.50 "
Centreville and Kingsburg...................	6.00 "

King's River and Fresno		6 to 1.70	"
Fresno Laterals		1.2 to 6.40	"
Kern county canals		.39 to 2.60	"
Kern county, sandy soils	1. to 2.	1.60	"
Kern county, sandy loam	.39 to 1.3	0.87	"
Campine, Belgium, sandy		2 to 10.00	"
Erie Canal	.25 to .80	0.60	"
Carpentras Canal, France		1.20	"
Marseilles Canal		0.40	"

GAINS FOUND IN CANALS.

In many cases the canals serve as drainage ditches and are found to gain in volume instead of loss. Several examples may be noticed in the tables, as the Empire canal, the North Farm lateral for a portion of its length, the Prairie Ditch, the Pleasant Valley and Lake canal, etc. It is frequently noticed that some canals have water even when their supply from the river is shut off. This is often found to be true with the ditches in river bottoms, originally built to take water from the river, but which, with the irrigation of the upper lands, have now become practically drainage ditches. Every old irrigated valley in the state has such instances.

In the case of the Hottel mill race at Fort Collins, not elsewhere mentioned, which was measured in the fall of 1897, a gain of over 4 sec. ft. was found in a distance of two miles.

The gains are manifestly more likely to be found in deep canals than in the shallow laterals.

VARIATION OF LOSS WITH DEPTH.

The amount of seepage increases with the depth of water in the channel. This is principally from theoretical considerations, but has observational confirmation. The exact relation must depend on the relative losses through the banks and through the bottom or on the relative width and depth of the channel. As the soil is rarely uniform for any considerable distance, the results from theoretical considerations can only be a guide as to what to expect. When the loss is solely through the banks there is reason for thinking it may vary nearly as the cube root of the square of the depth, that is, on doubling the depth, the loss would be nearly three times as much; on quadrupling the depth the loss would be nearly eight times as much.

Some interesting observations by J. C. Trautwine, Jr., Chief of the Bureau of Water of Philadelphia, are given in

Bulletin 45, on Losses from Reservoirs, page 12. It was found when the water was 20 ft. deep, the loss amounted to .15 inches per day; when 25 feet to .24 inches; when 30 ft. to .46 inches, but on lowering the water it was found that the loss did not become as small as the same depth before the reservoir had been filled. The loss at 20 ft., after the reservoir had been full, remained at .28 inches instead of reducing to .15 inches observed before.

Some observations by Keelhoff on small ditches have already been mentioned. In these more loss was found when the water was 10 inches deep than when 2 inches deep.

In the case of the North Farm Lateral, where two measurements were made with different amounts of water in the canal, a greater depth of loss is shown with the larger head. The depth of loss averages .8 with the head of 200 sec.-ft., and .4 ft, with a head of 90 sec.-ft.

By arranging the losses according to the amount of water in the canal, we find that the observations given in table VI show clearly that the smaller the amount of water the less is the depth of loss, though the greater the per cent. the loss is to the amount in the ditch.

Omitting the days on which the water had dropped, in which cases the water returning from the saturated banks reduces the apparent loss, and likewise leaving out of account those days in 1894 on which doubt is cast by showers, the following table is obtained:

Amount of Water. in Ditch.	No. Cases Taken.	Loss in Carriage. per Cent.	Loss in Depth. Inches.
0 to 2 sec. ft.	4	50	4.5
2 to 4		estimated 26	6.3
4 to 6	6	19	7.5
6 to 9	6	17	8.5

THE EFFECT OF TEMPERATURE ON LOSSES.

It is undoubtedly true that the amount of seepage will be affected by the temperature of the water, and though the temperature was always taken, no attempt is made to allow for the temperature in the present report. The effect of temperature is evident in the increased flow into streams as shown in Bulletin 33, in drains, and it causes a corresponding effect on the loss from canals.

Using the equation representing the effect of temperature on the velocity of flow as given in bulletin 33, p. 46, and considering the amount of seepage at freezing temperature as unity, the loss at other temperatures may be expected to be approximately as the following amounts:*

* Note in Engineering News, by L. G. Carpenter, 39:422. Also note 40:26, July 14, 1898, by Allen Hazen, giving practically same ratios from his own measurements.

Temp., F.	Velocity.	Temp., F.	Velocity.
32°	1.000	72°	1.860
42°	1.195	82°	2.109
52°	1.403	92°	2.372
62°	2.109	102°	2.649

In warm weather the loss is therefore greater than in cold, and the loss at 80° temperature of the water would be twice as much as if it was at freezing temperature; or the loss at 70° would be about one-third more than at 50°.

LESSENING SEEPAGE.

Of the conditions affecting seepage, the one which can most readily be controlled, and in fact the only one, is the character of the canal bottom or the bottom and sides. No soil is absolutely water-tight, but there is a great difference between the perviousness of the different soils, which range through all degrees of clay to sand and gravel. Clay of the quality known as adobe, essentially a clay from which all vegetable matter has been extracted by action of alkaline carbonates, is well known to be nearly water-tight.

A layer of fine material, as of fine silt, makes the passage of water so much more slow and difficult, that its effect is well known and is shown in a number of cases in the measurements reported in this bulletin. Even water that is apparently clear contains enough matter to lessen the rate of filtering in a few weeks time in the large filters for city water supplies.

The silt carried by canal waters is sufficient to greatly lessen, and in many cases to practically stop the seepage, but to do this the velocity of the water must be slow enough to permit the silt to be deposited.

A constant current tends to prevent the settlement of sediment. If the current is swift enough to erode the bed then not only is the sediment kept from dropping and filling the pores, but the surface is swept and the losses will remain large.

Hence defective alignment of the canal, too sharp curves causing the current to strike and erode the banks, are conducive to losses. Some canals have found it desirable to straighten the line of their canal to lessen the troubles of maintenance, and in so doing have also lessened the loss from seepage.

Any way in which the canal may be silted up, or be permitted to form a layer of silt, thin though it be, will tend to lessen the seepage.

Hence checks which some canals have found it necessary to construct for water distribution, cause slack water

and thus permit the deposit of silt. There are many places where the effect has been immediately shown. The water-soaked lands become dryer and land which had been impassable became dry enough for passage and cultivation. So as silting lessens the seepage, on the other hand the reremoval of the silt coating may cause the leakage to be as great as ever.

A case in point is the Greeley canal No. 3, as mentioned in Bulletin 33, pp. 49 50. When first built considerable damage was done from the rising of the ground waters and flooding of cellars in some parts of the town. After a few years the cause of complaint disappeared, silt having filled the bottom of the canal. In 1895 sand was obtained for building purposes from the bottom of the ditch at the crossing of a ravine. The top layers of the ditch bottom were found to be partially cemented. Within a few months after water was again turned into the ditch complaint arose regarding the influx of water in the town cellars. When water was turned out of the canal, the water in the cellars began to go down within ten days and in three weeks had fallen 6 inches, and in two months 18 inches. A measurement made above and below the suspected point showed a loss of 5.06 sec. ft. in a distance of 760 feet, or equivalent to a depth of 30 feet per 24 hours over the surface covered by the canal.

A drain sewer had been built by the City of Greeley to drain the region below this part of the town. It was stopped up at the time of the measurement, but v hile thus failing to remove the water, the loss from the canal was excessive as shown by comparison with the losses from other canals. The damage led to requests from the people in that part of town to correct the defects in the ditch. The city feared that an attempt to remedy the condition would be a confession that it was to blame. In 1896 a team worked for part of a day in hauling in clay and puddling this section of the canal, and the complaint in 1896 and 1897 was small.*

In the case of the Fort Morgan canal, given in table 5, there is an opportunity to compare the losses from a channel when freshly used, and after having been used for a year, silt presumably having settled.

In 1895, at the time of measurement, water had been turned into a new section two miles long for a couple of weeks. The loss was found to be 11.48 cu. ft. per second.

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*July 20, 1898, this portion was again measured and loss still is a depth of over 18 feet daily.

Almost a year later the same section gave a loss only one-half as much, the change being ascribed to the silting which had taken place in the meantime.

The use of sediment is the most practicable method of reducing the loss from seepage. In California both the main ditches and the laterals are often cemented, as they are in Mexico. Their canals are much smaller than the canals in Colorado, the value of water is much greater, and hence the amount which could be expended for the saving of water would be greater than could be profitably expended under Colorado conditions.

On some California canals the channels have been lined by cementing directly on the earth. This would not be possible to do successfully under the colder winters of Colorado.

Under some conditions, as where water is exceptionably valuable, it may become profitable to go to considerable expense to save the loss from seepage; to pave the sides or bottom if necessary, to concrete the canal through in our climate this is not likely to be satisfactory, or to pipe the ditch.

Evidently the question returns to the value of water and the amount of loss. The commercial value of a cubic foot per second of water is not less than $500 in any place in the state, and in few places would it be considered as high as $3,000. This is the nominal second-foot which actually is not constant in flow. Under farming conditions $1,200 would probably represent the average value. The annual value may be considered as not less than $50. To the farmer using the water its productive value is far more; or the individual who uses the water can profitably expend more than any one else.

The farmer who could thus save as much as 2 cubic feet per second could afford to expend $100 per year if necessary for that purpose. But until fully convinced of the efficacy of methods of saving water, few would care to risk so much.

In many cases the losses are excessive. Under fair conditions they be as much as two feet per day.

The losses vary with the different formations through which the canal passes, or the different character of the soil. Porous gravels are notoriously leaky, while the clayey soils, or gravel with a suitable admixture of finer material and clay, may hold water satisfactorily. In some cases the section of the channel can be enlarged at the leaky place and filled with finer material, or silt allowed to settle, for in most

cases a thin layer is sufficient to check the leakage very much.

LOSSES AT DIFFERENT FORMATIONS.

The effect of different strata is shown in the measurements of the seepage increase of streams. In the case of the Cache a la Poudre there are several stretches in which, notwithstanding the large gains in the river as a whole, there is an apparent loss of water.

In the Rio Grande river in Colorado marked losses were found for a portion of its length in the San Luis valley, amounting to 75 cu. ft. per second in a distance of 15 miles. The loss was noticed in 1896 and verified in 1897.

Similarly in the case of the Arkansas river, a loss is found in several places, but of less amount than found in the Rio Grande.

EFFECT OF PREVIOUS CONDITION ON LOSS.

The previous conditions of the bed of the canal, or stream, will materially affect the loss experienced in the canal or river bed. If the bed has been dry and has become heated as well, the amount of water which is absorbed by the bed when water is turned into the canal, is surprising to one who is not acquainted with the peculiarities of the flow of water under such conditions. The layer of dry soil absorbs the water with avidity. It will take up about one-third of its volume of water, and the amount of water thus absorbed is in addition to the amount which is flowing through the soil under steady conditions. The effect is to greatly increase the time required to send water through a ditch after having been dry, and on the longer ditches days may be taken to send water through the ditch, while when already soaked up a very slight change at the headgate is quickly felt throughout the length of the canal. It is because of the loss from this source that the attempts to run a moderate amount of water through streams with sandy beds have not been successful.

On the other hand, with falling water, a considerable amount of saturated soil is exposed. Water oozes from the banks and the supply thus received retards the fall of water. Sometimes when the banks are gravel, the outflow appears in streams and is so rapid and abundant that it may cause a slipping of the bank. Experienced canal men have a well founded objection to lowering water suddenly and considerably and though some, mistakenly, think that the pressure

of the water holds the gravel in place, the effect observed is a real one.

In consequence a canal with rising water will have more and with falling water less than the normal loss, or more than the normal gain. This is shown in numerous cases with the records on the North Poudre canal. The length of time during which this will affect the conditions depends on the area and extent of the gravel beds near the channel. The principal effect passes off in a short time, for as the line of saturated soil becomes further removed from the channel, the movement of water is much more slow.

One consequence often realized in practice is that if water is to be run through a long canal, the division can be made better and fairer if the water is run completely through the canal before opening the lateral gates. The whole of a small stream of water may be required to satisfy the thirsty sand. A large stream may accomplish the same purpose in a shorter time and with less loss. Hence often it is better to use the whole stream if necessary to wet the bottom of the canal for its whole length, before beginning the division of water, and if the canal is run in sections, to begin the distribution at the lower end of the canal is the better way. If a small stream only is used, nearly all may be taken to wet up the channel and leave little for the lower users.

CONCLUSIONS.

1. The losses from evaporation are relatively insignificant compared with the seepage losses from most canals. In the cases most favorable to evaporation and least favorable to seepage the evaporation is not over 15 per cent. of the seepage.

2. In the case of reservoirs it was concluded in bulletin 45 that the seepage was less important than the evaporation. This is different from the results found in ditches, not because the evaporation is less, but because the seepage is much more.

3. The losses are sometimes enough to cover the whole canal 20 feet deep per day.

4. The loss in clay soils is less than in sandy or gravelly soils, but rarely as small as 3 inches daily.

5. The loss is greater when water is first turned in than after the bed has become saturated.

6. Sometimes the canals are found to gain for the whole or part of their length, or the canals may act as drains. This is more likely to be the case when the canal

is deep in the ground, when crossing lines of drainage, or when located below other ditches or irrigated tracts.

7. In the prevailing Colorado soil, when not intercepting seepage, the loss may be put provisionally at from 1 to 2 feet per day over the whole surface of the canal. In clay soils it is less, but still nearly one-half as much.

8. The loss in carrying water in small quantities, is relatively larger than in carrying large amounts. The increased depth of water means increased leakage, but the carrying capacity increases faster than the leakage.

8a. From the standpoint of economy, it is wasteful to run a small head. It is more economical to run a large head for a short time. In the management of small ditches the time system of distribution can be introduced to advantage, saving time and labor as well as water.

9. It is wasteful to use two ditches or laterals when one would serve.

10. The loss increases with higher temperature, being about twice as much at 80° as at 32°.

11. The loss increases with greater depth of water, but the exact relation needs further investigation.

12. The loss will be lessened by any process which forms or tends to form an impervious lining or coating of fine material, as of clay or silt. The silt, consisting of fine sand, improves many soils. Clay is better and especially limy clay, the lime with the clay forming an almost impervious coating.

13. Cement linings as used in California and Mexico are not warranted by the conditions in Colorado, nor would the weather conditions be favorable. Nor is the use of wooden stave piping for this purpose likely to be profitable in many places in the State, if at all on the larger canals at present. The silting process applied with discrimination will accomplish much at smaller cost.

14. On small laterals glazed sewer pipes may save annoyance often connected with the carrying of water in laterals for considerable distances, which, with the saving of water, may make its use an object. One of the supply laterals of the Colorado Agricultural College is of vitrified sewer pipe, over 4,000 feet of 12-inch pipe being used.

15. Some particular sections in canals are subject to much greater loss than the canal as a whole. Hence water can be saved by locating the leaky place and remedying it. This may be desirable to do while it would be unprofitable to treat the whole canal.

16. There are many places where it would be advan-

tageous to combine two ditches, by this means saving not only the loss of water, but saving superintendence and maintenance charges. With increased confidence in the accuracy of water measurement, reluctance to such consolidations should lessen.

17. The depth of losses from laterals is probably greater than in the main ditches. The laterals are less permanent, are steeper, have less silt, and are more poorly cared for.

18. There must be some arrangement of ditches and laterals which is the most economical for given conditions, so that the aggregate of the losses of the whole system will be a minimum. Certainly the location and arrangement of the laterals for carrying water from the main ditch is worthy of consideration by the management of the main canal and the importance increases with the size of the canal and the width of the strip it serves.

19. It is not to be understood that the whole of the loss from the ditches is lost to the public wealth of the State. Some, perhaps much, of the loss, may re-appear as seepage in lower ditches or in the main stream and again be used. It is, however, lost to the particular ditch and incidentally is destructive to much land. With all practicable methods of prevention, there will still be abundant loss. It should be to the advantage of the individual ditch to prevent such loss as far as practicable.

20. A general statement of the total amount of loss of water must be made and accepted with reservation. It would appear that in the main canals from 15 per cent. to 40 per cent is lost, and in the laterals as much more. It would thus appear that not much over one-half, certainly not over two-thirds of the water taken from the stream, reaches the fields. In the most favorable aspect, the loss is great, and is relatively greatest when the loss can be least afforded, viz.: when the water is low and the ditches are running with reduced heads.

21. There are some 2,000,000 acres of land irrigated in Colorado and the value of the water rights at a low estimate is as much as $30,000,000. (The census estimates the water rights as worth $28.46 per acre.) On this basis, the capital value of the water lost by seepage in the canals and ditches may be put at from six to ten millions of dollars. From the evidence at hand at present this seems a low estimate.

PUBLICATIONS OF THE SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING.

BULLETINS.

No. 13 -On the Measurement and Division of Water. Oct., 1890, 46 pp.
Some principles applicable to dividing water. Conditions to be met by modules. Descriptions of weirs and their conditions for accurate use; first English description of the Cippoletti trapezoidal weir. Tables for the rectangular and trapezoidal weirs, with and without contractions.
Second edition July 1891. Editions exhausted.

No. 16 -Artesian Wells and Their Relation to Irrigation. 1892, 28 pp.
Including maps showing the Denver and the San Luis basins, and indicating the probable limits of the latter, closely confirmed by the wells since sunk.
Edition exhausted.

No. 22—Preliminary Report on the Duty of Water. 1892, 32 pp.
Giving several years measurements on the amount of water used on crops of alfalfa, wheat, oats, native hay, and on canals irrigating many thousand acres, all in the Cache a la Poudre valley, with some discussion on the absurdly high duties sometimes reported, and on the ultimate duty of water.
Edition exhausted.

No. 27—On the Measurement and Division of Water. 1895, 42 pp.
Revised edition of No. 13, with additional matter, especially new tables computed for weirs of unit length and for depths measured in inches. Also tables for correcting for velocity of approach, so as to render the tables applicable to cases where the space in front of the weir becomes silted up.
Edition exhausted.
The tables have been reprinted in Report of the Colorado State Engineer for 1895–6.

No. 33—Seepage or Return Waters from Irrigation. Jan. 1896, 63 pp.
Reporting measurements in detail on the Poudre river and on the Platte river made to determine the increase in those streams from return waters from irrigation. Discusses the origin of that increase and the connection with the area irrigated and the amount of water applied in irrigation. Shows connection between the amount and the temperature, etc.
Copies still to be had on application.

No. 45—Losses from Reservoirs by Seepage and Evaporation. May, 1898, 32 pp.
Eleven years observations of evaporation at Fort Collins, and several years observations on floating tanks. Two winters observations on losses from seepage. Some discussion of economy of storage at high altitudes.

No. 48—On the Losses from Canals from Filtration or Seepage.

Annual Reports Forming Part of the Annual Reports of the Agricultural Experiment Station.

1888—First Annual Report of the Agricultural Experiment Station, 250 pp. C. L. Ingersoll director.
Report of Meteorologist and Irrigation Engineer, 70 pp.
Description with illustrations of instruments.
Meteorological observations in detail.
Table of observed sunshine by days and comparison with New York.
Table of soil temperatures.
(Tables reprinted in Report of Secretary State Horticultural Society, 1889.)

1889 Second Annual Report of the Agricultural Experiment Station, 1889, 136 pp. C L. Ingersoll, director.
Report of Meteorologist and Irrigation Engineer, 28 pp.
Table of extent of irrigated area in Colorado.
Monthly precipitation for several years and at various co-operating stations

Daily range of temperature.
Tables of amount of shnshine observed at Fort Collins, Rocky Ford and Del Norte.
Observed and computed evaporation from water surface.
Weekly means of soil temperatures at several places.

1890 -Third Annual Report of the Agricultural Experiment Station, 228 pp. C. L. Ingersoll, director.
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Depths taken by the No. 2 canal.
Irrigation statistics, 1890.
Acres covered by ditch.
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Meteorological tables: Precipitation.
Daily dew point and relative humidity by days.
Evaporation, summary of results.
Evaporation at Del Norte.
Evaporation on a reservoir.
Sunshine by months at three stations, compared with New York.
Sunshine, forenoons and afternoons.
Sunshine for days, by sunrise to 9 a. m.; 9 to 12; 12 to 3; 3 to sunset.
Sunrise by days throughout the year, three stations.
Actinometer readings, 1890.
Daily temperatures, 7 a. m to 7 p. m., max., min., throughout the year.
Table of range, daily, throughout the year.
Table average and greatest range by months.
Weekly soil temperatures, depths from 3'' to 6 ft., three locations.
Table of extremes.
Daily mean barometer.
Annual summaries at Agricultural College, Del Norte, Rocky Ford.

1891 -Fourth Annual Report of the Agricultural Experiment Station, 130 pp. W. J. Quick, director.
Reports of the Meteorologist and Irrigation Engineer, 69 pp.
Tables of precipitation for 15 years at Fort Collins, at 19 co-operating stations.
Change of precipitation due to elevation.
Dew point and relative humidity, 1891.
Return or seepage waters.
Evaporation, comparison of computed and observed.
Average daily evaporation.
Comparative evaporation at three stations.
Notes on duty of water, on actinometry.
Sunshine tables as in 1890.
Weekly means of soil temperatures.
Air temperatures by days.
Terrestrial radiation by days.
Average barometer by days.
Comparative tables observations at Fort Collins and Manhattan, 3,000 ft. higher.
Annual summaries, Fort Collins, Monument, Rocky Ford, Manhattan.

1892 --Fifth Annual Report of the Agricultural Experiment Station, 68 pp. W. J. Quick, director.
Report of the Meteorologist and Irrigation Engineer. 6 pp.

1893—Sixth Annual Report of the Agricultural Experiment Station, 84 pp. Alston Ellis, director.
Report of the Meteorologist and Irrigation Engineer. 7 pp.

1894—Seventh Annual Report of the Agricultural Experiment Station. 112 pp. Alston Ellis, director.
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1895—Eighth Annual Report of the Agricultural Experiment Station. 64 pp. Alston Ellis, director.
Report of the Meteorologist and Irrigation Engineer. 7 pp.
1896—Ninth Annual Report of the Agricultural Experiment Station. 113 pp. Alston Ellis, director.
Report of the Meteorologist and Irrigation Engineer. 5 pp.
1897—Tenth Annual Report of the Agricultural Experiment Station. 110 pp. Alston Ellis, director.
Report of the Meteorologist and Irrigation Engineer. 24 pp.
Discussion of operations of the year, results and investigations desirable to make.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 49.

Meteorology of 1897, With Illustrations.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

SEPTEMBER, 1898.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

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Fort Collins, Colorado.

EXPRESS, FORT COLLINS

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FORT COLLINS, COLORADO.

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METEOROLOGY OF 1897.

With Illustrative Diagrams and Descriptions of Instruments.

BY L. G. CARPENTER AND R. E. TRIMBLE.

☞A table of contents is to be found at the back.

§1. The following bulletin gives the principal, though not all of the meteorological observations made at the Agricultural Experiment Station during 1897.

§2. The peculiarities of the climate are such, that while its vagaries give less cause for comment in Colorado than in a more moist climate, nevertheless the general characteristics are well worthy of understanding, and necessary, indeed, for one whose operations may be affected thereby. In general, facts given in tables are not easily apparent, hence the following tables have been retained until they could be accompanied by the diagrams here given. The tables with the diagrams, it is hoped, will show the course of the changes and reveal the general characteristics of the climate, and be more useful than as a mere record of the year.

§3. The great variation in altitude in the state, ranging from less than 4,000 feet at the eastern border to over 14,000 feet at the summit of numerous peaks, causes a change in climate greater than between New Orleans and Winnipeg, and while Colorado east of the mountains has a mean temperature the same as New York, the temperature of the high peaks is lower than that of Spitzbergen. Therefore, when we speak of the climate of Colorado we have great differences to consider. Still, cultivated and irrigated Colorado is of relatively small range in elevation, and fortunately Fort Collins is as typical as any single place which could be selected.

§4. Among the general characteristics of Colorado are:

The small rainfall—from one-half to one-third of that east of the Mississippi.

The dryness, indicated by the low relative humidity, promoting rapid evaporation, and causing an absence of

sensible perspiration as a rule, and less oppression than accompany the same temperatures in a more moist region.

Greater range of temperature.

A large percentage of sunshine, of great intensity, which, as well as the great range, is a consequence of the great dryness and rarity of the air.

One of the marked features is the presence of warm westerly winds known as Chinooks, a type present in mountainous countries under various names. While cold waves are not absent, the intensity is less than in the Mississippi Valley states. The conditions which result in blizzards of great intensity in the states, cause westerly winds with us, and some of the most pleasant weather of winter.

DESCRIPTION OF THE STATIONS.

§5. The Agricultural Experiment Station, at Fort Collins, is located at the base of the Rocky mountains about four miles from the foot hills, beyond which the mountains rise to the summit of the range, fifty miles westward. It is located about one mile south of the Cache a la Poudre river, and about forty feet higher, on the bench lands which are supplied with water for irrigation from this same stream. The college is in the midst of an irrigated area, which extends about three miles farther west, while both east and south there is no unirrigated land for a number of miles. The nearness of the mountains affects the climate in the amount and character of the clouds, in the temperature, in the precipitation, and in the direction and character of the winds.

The elevation of the office barometer, which is ten feet above the ground, is 4,992 feet as found by connecting with the levels of the U. P. D. & G. R. R. The latitude of the college is 40° 34′; its longitude, 105° 6′ west of Greenwich.

§6. The station at Cheyenne Wells which has been termed, perhaps unfortunately, the Rain Belt station, is on the Great plains, on the Kansas Pacific Railway (Union Pacific), near the eastern border of the state. It is a point where wells were sunk to a great depth to procure water. The elevation above the sea level is 4,278* feet. Its latitude 38° 50′, and longitude 102° 20′. The station is nearly one-third of the distance between the Arkansas river on the

* Preliminary unpublished results of the trans continental levels of the U. S. Coast Survey.

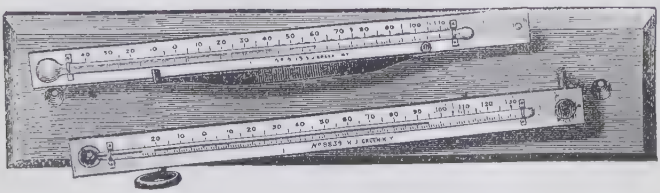
south and the Platte on the north, and it has the characteristic climate of the Great Plains. Mr. J. E. Payne has been the Superintendent and observer. The reductions have been made at the home station.

§7. The Arkansas Valley Experiment Station at Rocky Ford, is located on the south side of the Arkansas river, about 50 miles east of Pueblo and 240 miles from the central station at Fort Collins. This station is in the irrigated strip along the Arkansas, with uncultivated range extending south to the state line, and north to the Platte. The observations during the year have been interrupted by a change in the management of the station. Mr. P. K. Blinn severed his connection with the station the first of May, and Mr. W. F. Crowley took up the work the first of August. Observations have been carried on at this station since 1890, and most of the time continuously. The latitude of the station is 38° 3′, and the longitude 103° 45′, and the elevation above the sea level 4160 feet.

DESCRIPTION OF THE INSTRUMENTS.

§8. The standard for testing the thermometers is the Normal Standard Thermometer of Green, No. 5483. Besides the special care taken by Green in its manufacture, this was tested at the Yale Thermometric Bureau, and subsequently at the U. S. Weather Bureau The results not agreeing, it was afterwards sent to Professor W. A. Rogers of Colby University, who made a careful study of its peculiarities. All thermometers are tested at the freezing point, and those used for continuous observations are tested in comparison with 5483.

§9. The maximum and minimum thermometers are shown in Figure 1. The maximum thermometer is of the



(Fig. 1.)

Green pattern, in which there is a constriction in the tube just above the bulb. When the temperature rises, the mercury is forced past the constriction, but if the tempera-

ture falls, the constriction prevents the passage of the column of mercury, and the upper end of the column indicates the highest temperature since the last setting of the instrument. The minimum thermometer is the ordinary spirit thermometer with a sliding index in the tube. As the temperature lowers and the column shrinks, the index is pulled along by the surface of the liquid. When the temperature rises, the liquid flows past the index without carrying it along, and the upper end of the index thus indicates the lowest temperature since the previous observation,

WET AND DRY BULB THEMOMETERS OR PSYCHROMETER.

Fig. 2.

§10. For a portion of the time the ordinary pattern of stationary wet and dry bulb thermometers has been used. Since 1889 the sling thermometers have been used. In both cases the set consists of two thermometers as near exactly alike as possible, one of which is observed with its bulb dry, and the other, which has its bulb covered with thin muslin, is moistened with water. The ordinary set of wet and dry bulb thermometers is fixed in position, and the moistening of the bulb is accomplished by candle wicking which connects with a little water in a small vessel. The evaporation from the muslin cools the bulb so that the thermometer indicates the temperature of evaporation, which depends upon the amount of moisture that is contained in the air. The air next the bulb tends to become saturated, in which case the evaporation proceeds less rapidly, and the wet bulb does not fall so low as it would if a brisk wind were blowing. Hence the stationary psychrometer, where the air is more or less stagnant, is not as accurate as the sling psychrometer, which is essentially the same instrument, but is swung in the open air to obtain complete ventilation. In this case, the bulb is covered with

thin muslin and water is applied before the observation. The stationary form of psychrometer is especially unsatisfactory in freezing weather because it is difficult to obtain sufficiently rapid evaporation from the film of ice.

THERMOGRAPH.

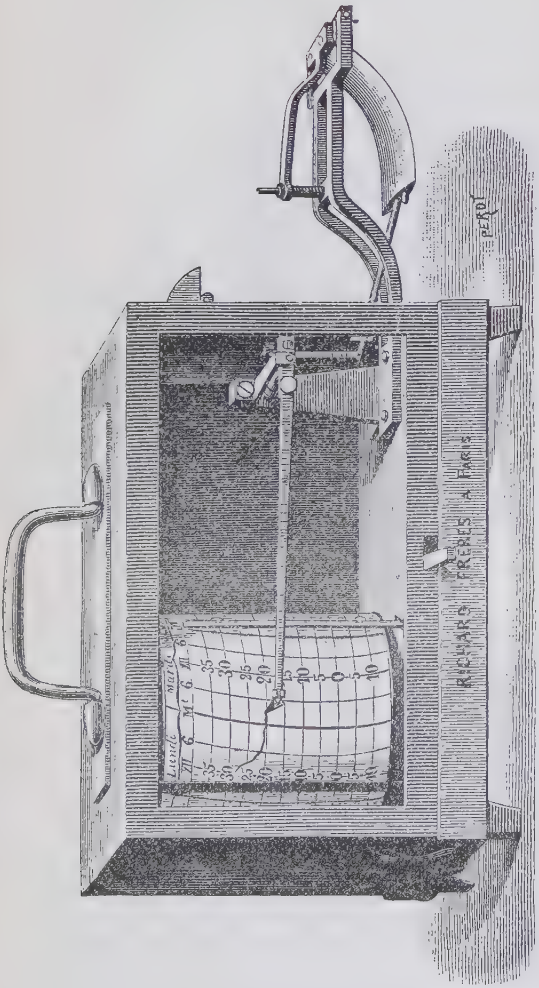


Fig. 3.

§11. Figure 3 represents the type of thermograph which has been used since 1890. This has been found to be a very satisfactory instrument in most respects. It is a pattern made in Paris by the firm of Richard Bros., from whom we have obtained a number of our self-recording instruments. The thermometer consists of a metallic tube, shown at the right of the instrument, which is filled with alcohol or ether. One end of the tube is fastened, the other free. As the temperature changes, the expansion of the liquid changes the curvature of this tube, and the movement of the free end acting through a series of levers, causes a pen to rise or fall according as the temperature increases

or decreases. The pen records on a paper wound on a cylinder. The cylinder is caused to revolve once a week by clock work inside the cylinder, working through pinions at the base. The record of temperature by the instrument has been satisfactory, but the clock work in this and other similar instruments has not been a good time keeper.

THE REGISTERING PSYCHROMETER.

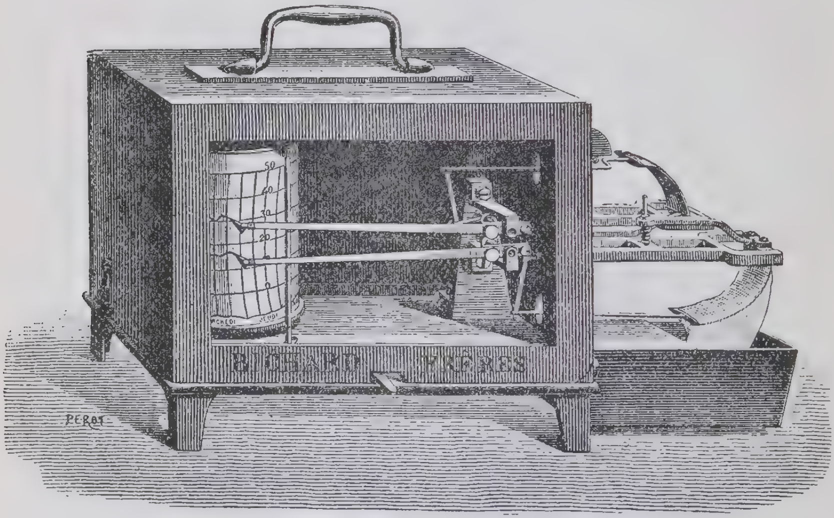


Fig. 4.

§12. This instrument, shown in Figure 4, is similar to the thermograph except that there are two thermometer bulbs instead of one, and two pens which record on the sheet. One of the bulbs gives the temperature of the air, while the other, covered with muslin moistened in water, records the temperature of evaporation. The two bulbs correspond to the wet and dry bulb thermometers of the ordinary psychrometer. To prevent interference with each other, the pen of the wet bulb is set about 10° lower than the other. The record of this instrument has been maintainded since 1891. The record of the wet bulb thermometer is not as satisfactory as that of the dry bulb, but affords an interesting indication of the changes in humidity between the regular periods of observation. Many times the changes which take place are sudden; sometimes cur-

rents of air pass, with very little change in the dew point. At other times the wet bulb thermometer will suddenly rise or fall, showing a marked change in the moisture conditions of the air without a corresponding change in temperature.

THE BAROMETER.

§13. The barometer which has been used was made by Green, and consists of a mercurial barometer with adjustable cistern. The height of the mercurial column is measured from the mercury in the cistern to the top of the mercurial column near the upper part of the tube. The mercury in the cistern is always brought to the same height by a screw in the bottom. The attached thermometer shows the temperature of the mercurial column. This is read at each observation, and as the mercury expands or contracts with change of temperature a correction is made to the readings of the instrument to allow for the expansion of the mercury, and also for the change in length of the brass scale at the side of the instrument. The heights given in the tables are the heights corrected for temperature, or are the pressures of the barometer for a uniform teperature of 32°, but measured by a scale of correct length at a temperature of 62°. The station has two barometers of this type, one of which was in use at the sub-station in the San Luis Valley for some years, until, with a change in location of the station, the barometer was injured.

BAROGRAPH.

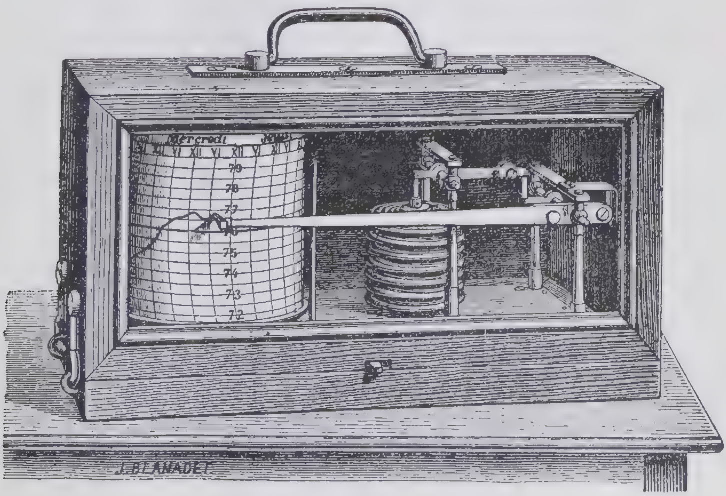


Fig. 5.

§14. Figure 5 shows the self-recording barometer which has furnished records since 1887. This is one of the instruments of Richard Bros., of Paris It consists of a series, eight in number, of hollow corrugated disks, the lower one fastened to the base of the instrument, the upper one to a lever connected with a pen. As the pressure increases, these disks are pressed together, and when the pressure decreases, expand, and thus, through a series of levers cause the pen to rise or fall. The instrument as a whole is a very satisfactory one. The instrument is supposed to be compensated for the effect of temperature by a little air left inside the disk. As a matter of fact the correction for temperature is incomplete, and varying temperature affects the indication of the instrument.

THE STATOSCOPE.

§15. The statoscope is essentially a magnifying barograph on the same principle as the one already described. It consists of one large, hollow disk which is connected with the exterior air through a tube closed by a stop-cock. In using this instrument, the pressures inside and outside the disk are equalized by opening the stop-cock. After closing the stop-cock the inside pressure remains as it was, and if the pressure outside increases the disk is compressed; if it diminishes, then the elasticity of the box causes the sides to expand. The disk is connected with the pen by levers, so that the pen rises or falls correspondingly. With change in temperature the pressure of the air in the disk alters, and the pen will rise or fall whether the outside pressure changes or not. A rise in temperature of the inclosed air gives an increased pressure in the disk, having the same effect on the pen as a decrease in pressure of the surrounding atmosphere. If the temperature lowers, then the inside pressure diminishes, or the effect on the instrument will be the same as an increase in the pressure of the outer atmosphere, and the pen will rise. The clock work makes one revolution in 52 minutes. During settled weather, or when there is little wind, this instrument shows that the pressure of the air changes steadily but without sudden fluctuations. In the case of heavy winds the fluctuations are very violent, as are shown in the diagrams here given.

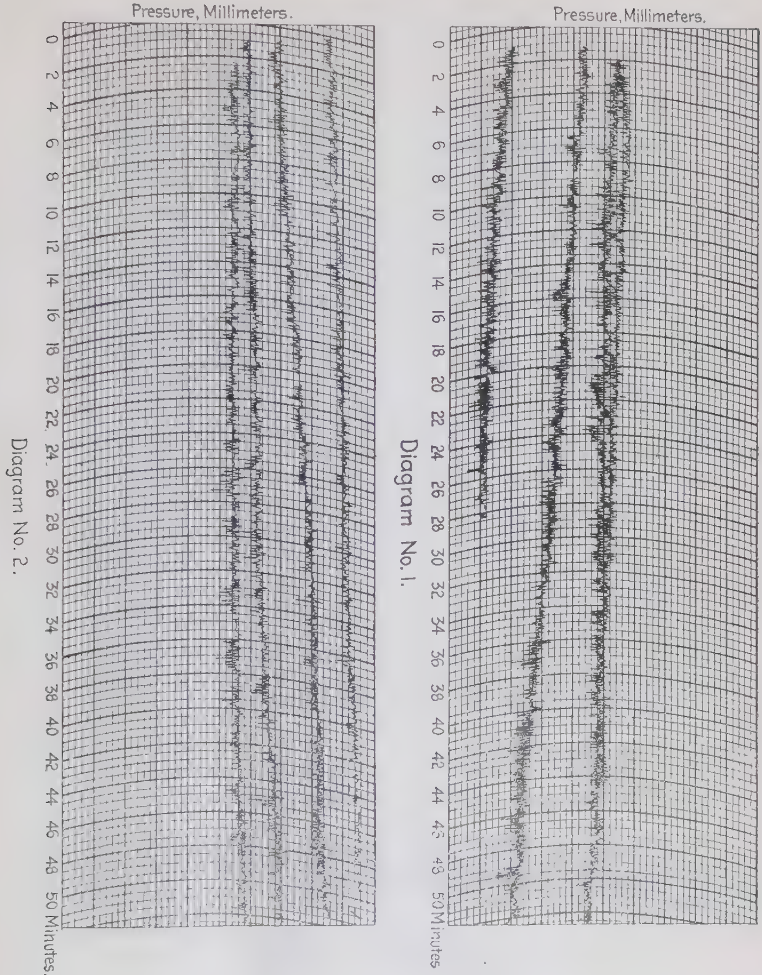


Fig. 6.

§ 16. On the diagram, Figure 6, the vertical scale indicates pressure, the horizontal scale, time. The heavier lines show periods of two minutes and the smaller ones 30 seconds intervals.

§ 17. Sheet No. 1, was placed on the instrument during a heavy wind from the west—known as Chinook—and the clock work started at 10:30 a. m. The clock work revolved five times before the sheet was removed, one revolution not recording owing to the exhaustion of ink in the pen. The

second sheet was placed on at 2:45 p. m. During the time of the observation the wind velocity per hour was as follows:

10 to 11 a. m....48 miles	12 to 1 p. m....52 miles
11 to 12 a. m....49 miles	1 to 2 p. m....49 miles
	2 to 3 p. m....48 miles

During the time shown by the second sheet the velocity was nearly constant, and was 44 miles per hour.

§18. The abrupt changes in pressure are noteworthy, and indicate the frequency of the more violent gusts, which, during the heaviest wind, is from eight to ten variations in 30 seconds. As the wind becomes slower, its gusty character is lost, the variation of the pressure dissapears, and the record shown by the instrument is a straight line. In the second diagram are periods of from 30 seconds to 2 minutes where the line is smooth. During these times there was a lull in the wind. The greater irregularities indicate the violent gusts proceeding and following the calm periods.

The diagram well shows the character of the wind at such times, and that the velocity of the wind per hour does not necessarily indicate the power of the wind to do damage which would be measured by the most violent gusts. The greatest velocity is attained only for a few seconds at a time, and the strength of structures must be sufficient to withstand these gusts of short duration.

RADIATION THERMOMETERS.

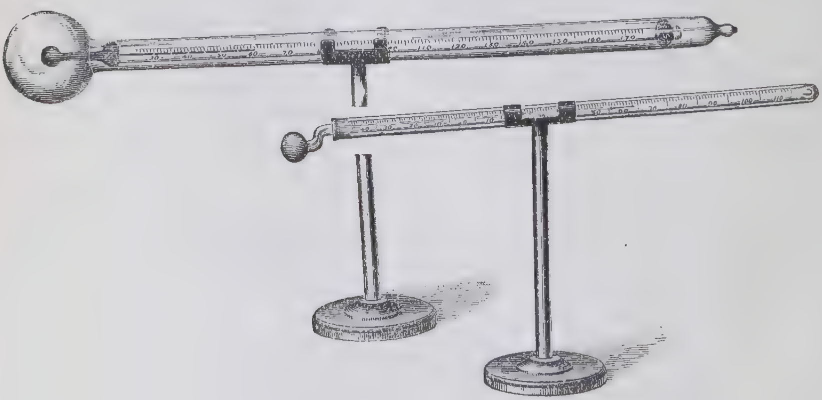


Fig. 7.

§19. The Maximum Solar, and the Terrestrial

Radiation Thermometers are shown in Figure 7. The solar instrument is an ordinary maximum thermometer with blackened bulb in a glass enclosure. The thermometer is measurably protected from the temperature of the air but without a corresponding instrument with a bright bulb, is of doubtful scientific value. We have found that it is difficult to obtain instruments of this pattern of sufficient range, the temperatures under our intense sunshine causing the breakage of the bulb. The principal reliance is now placed upon the Arago-Davy form of conjugate thermometers, or actinometer, consisting of two thermometers, each with a bulb one centimeter in diameter, placed in glass enclosures from which the air has been exhausted. The difference between the readings of the two instruments is not proportional to the radiation, but gives a means of determining the intensity after the constant of the instrument has been determined, as has been shown by Professor Ferrel. The convenience of these instruments is that they may be read as easily as an ordinary thermometer, and do not require the skill and special attention required by most forms of actinometers.

Fig. 8.

§ 20. The terrestrial thermometer is an ordinary minimum thermometer with the stem protected from radiation. It is placed near the ground, with the bulb exposed to the sky. The difference between its temperature and the readings in the instrument shelter, show to a great extent the effect of the cooling due to radiation. It is intended that it shall be placed over grass, but the changes in the location of the instrument plat have not always permitted this.

HOOK GAGE.

§ 21. The evaporation has been measured by the hook-gage shown in Figure 8. The hook is submerged, and the small elevation of the water surface produced as the hook approaches the surface permits the height of the surface to be determined within less than 1–1000 of a foot. Water is maintained in a tank three feet cube of galvanized iron, sunk flush with the ground. Observations are made twice daily during the summer season, April to September,

when the early darkness interferes with the observation at 7 p. m. After the water freezes in November, the tank is not disturbed except at the end of the month, when the ice is broken and measurement made.

EVAPOROMETER.

§22. Figure 9 represents the evaporometer which has been used to determine the amount of moisture used by a plant in its growth. It is adapted only to small plants, but with them serves to show the varying demands of the plant from day to day.

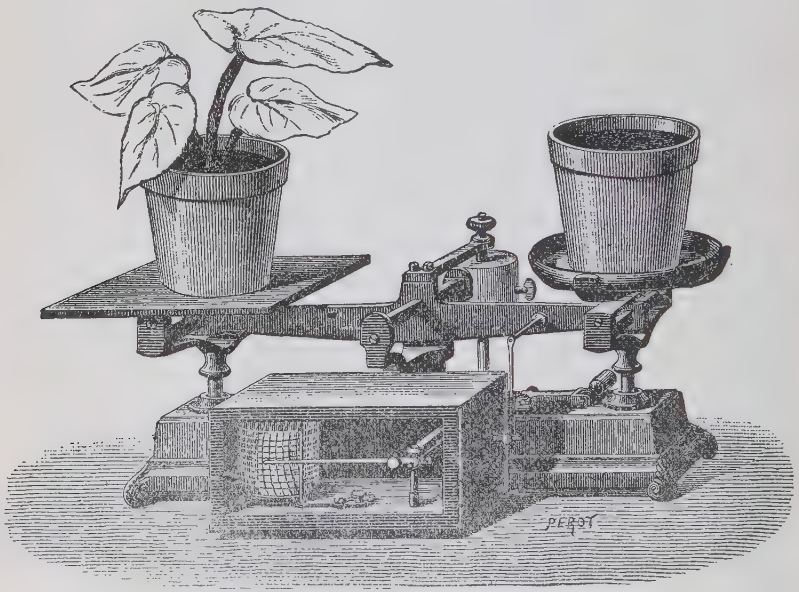


Fig 9.

SOIL THERMOMETER.

Fig. 10.

§23. Soil temperatures have been taken at different depths by thermometers with stems extending from the surface to the depth whose temperature is wanted. The thermometers, of the type shown in Figure 10, are of the pattern made by H. J. Green, Brooklyn, N. Y., protected by a wooden covering, which partly prevents the action of the temperature of the intermediate soil.

SUNSHINE RECORDER.

§24. The amount of sunshine is recorded by the Pickering sunshine recorder. This consists of two semi-cylinders—one for afternoons, and one for forenoons. They are essentially pin-hole cameras. The hole is in the flat surface and the image of the sun is cast on the curved side of the cylinder opposite, which is covered with a sheet of photographic paper sensitive to the light. We have added wires whose shadow indicates the noon hour. The face of the cylinder is moved a notch daily, bringing the trace of the sun's rays on a fresh surface of the paper. As long as the sun shines it makes a line, in which there is a break whenever clouds obscure the sun. Hence the record, after being fixed by a bath so as to be no longer acted on by light, consists of a series of broken lines, one line across the paper for each day, the extent of sunshine being shown by the lines, the amount of cloudiness by the breaks. The lines can then be measured and converted into hours and minutes. The sunshine near sunset and sunrise does not record for about half an hour, this is counted in our figures according to the character of the day.

EXPLANATION OF THE TABLES.

§25. A dry bulb temperature is that of the ordinary thermometer. This observation is made at 7 a. m. and 7 p. m. The instrument is placed in an instrumental shelter to shield it from wind and from radiation from the ground and outside objects. The wet bulb reading is that of a thermometer with the bulb covered with fine muslin and wet in water. The cooling caused by evaporation lowers the temperature of this thermometer below that of the similar dry bulb. This reading is sometimes spoken of as the

temperature of evaporation. The drier the air, the lower does this thermometer read. In some of the summer months the difference is found to be as great as 15° or 20°. Attention has been called to the fact that this temperature would indicate approximately the temperature which the human body experiences, as the body is approximately in the condition of an instrument that is moist, and whose temperature is less than that of the air. It has therefore been proposed to call this the Sensible temperature. This term, which is free from objection during the summer months, is entirely misleading for temperatures below freezing. The observations are made by a Sling Pyschrometer consisting of two exactly similar thermometers placed side by side. These are swung in the air, in order to cause the rapid evaporation which will only take place by the renewal of air in contact with the bulbs.

§26. The dew point and the relative humidity are obtained by calculation from the observations on the dry and wet bulbs. This is done by the aid of tables, still in manuscript, prepared in 1889, and based on Ferrel's researches. By the temperature of dew point, is meant the temperature at which the air is saturated with the amount of moisture it contains. At all temperatures the air contains moisture. Ordinarily this is invisible, and the air does not contain all that it will hold, or it is not saturated. At low temperatures it will not hold nearly as much as at high temperatures. In consequence, when the air is cooled without loss of moisture, it approaches saturation, or the relative humidity is increased, while the dew point remains the same. When saturation is reached, (when the relative humidity is 100 per cent, or when the dew point is the same as the air temperature) any additional cooling will cause some of the moisture to be condensed into a visible form. When a large mass of air is cooled, it may be as a cloud; or if the air is cooled by contact with some body below the dew point, it may be as dew or frost. The temperature of dew point thus indicates the temperature of the air at which the amount of moisture actually present causes saturation. Thus every time when the dew point is the same, the absolute amount of moisture present is the same. The relative humidity expresses the percentage that the moisture actually present bears to the amount of moisture which would saturate the air at the temperature shown by the dry bulb. A relative humidity of 100 per cent indicates complete saturation.

§27. The daily mean dew point and daily mean relative humidity are the means of the corresponding dew points and relative humidities from observations at 7 a. m. and 7 p. m.

§28. The maximum and minimum temperatures are obtained by self-registering thermometers, which record respectively the highest and lowest temperatures that take place between the times of observation. The mean temperature for the day is the mean of these two readings. In general, this is higher than would be obtained from the mean of the air temperatures at 7 a. m. and 7 p. m.

§29. As great variation in temperature is characteristic of the climate of the arid regions, a column showing the daily range is therefore given. It will be noticed that the average daily range for the year is nearly 30°, and that the range of certain days may exceed 50°, an amount which is unknown in the regions east of the Mississippi. It is in consequence of such variation, that while the temperature seems moderate, if not warm, it is not uncommon on days when the temperature has been below zero in the morning, to find an overcoat unnecessary at noon. The same valuable features are characteristic of the summer climate, for while the temperature of the day may rise to 90° or over, the range gives cool nights, and the conditions for physical rest.

§30. The barometer readings are those of the mercurial barometer, read twice daily. In addition to this a barograph is also used. It will be noticed that the barometer varies from day to day and from month to month.

§31. Terrestrial radiation serves to indicate the effect of radiation on the temperature of the air next to the earth's surface. The reading of the instrument gives the temperature indicated by the minimum thermometer placed with its bulb a few inches above the grass surface. This is nearly the temperature of the air at that point. This instrument is placed about six feet lower than the instruments in the shelter close by. The amount that the radiation thermometer is lower than the minimum thermometer in the shelter is placed in the column of radiation.

§32. The important effect of radiation is that it may cause frost to occur, even when the lowest air temperature is above freezing. It will be noticed, that during the months of April, May and June, the temperature near the ground becomes 4° or 5° lower than the temperature of the air six feet above the ground, and that at times it may descend 10°

or more below the air temperature. Hence it is not uncommon to find frost occurring, even when the lowest temperatures of the night, indicated by a thermometer at the ordinary height above the ground, has not descended below 40°.

§ 33. The precipitation is measured by the use of a standard rain gage exposing 50 square inches of surface. If the precipitation occurs as snow, the measurements are more unreliable, as the snow drifts and the rain gage does not give reliable results. Better results are obtained by distributing boards flat on the ground, and after the storm choosing one which seems not to be affected by air currents, obtaining from it, by inserting the rain gauge, the amount falling on a surface the same as the gage and melting the snow. There is a great difference in the amount of moisture in a given amount of snow according to its condition, whether light and powdery, or damp and heavy. On the average, the amount of moisture is 1-10 the depth of the snow.

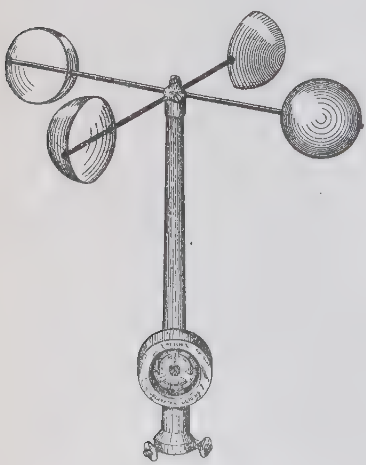


Fig. 11.

§ 34. The wind is measured by the Robinson Anemometer. The standard instrument is placed on top of the tower of the college building, and is connected by wires with the office of the Meteorological section, so that every mile of wind that passes is registered on the recording cylinder. The instrument is about 60 feet above the ground. Trees surround the campus with an elevation of about 40 feet. The tower extends about 20 feet above the roof of the adjacent building.

§ 35. Solar radiation is measured by means of the actinometer. This instrument is of the Arago-Davy form, consisting of two thermometers with spherical bulbs one centimeter in diameter, surrounded by a glass enclosure from which the air has been exhausted. These are placed with their bulbs uppermost exposed to the sky. One of the two has its bulb covered with lamp black and absorbs the radiations, and indicates a higher temperature. The readings of these instruments are given in Centigrade degrees, which may be

put into Fahrenheit degrees by multiplying the reading in centigrade by 1.8 and adding 32°. By means of a special series of observations, indications of this instrument may be interpreted and expressed in calories, or units of heat.

§ 36. To say that the heat received is one calorie, is to say that the heat received on one square meter is sufficient to heat one kilogram of water one degree C. in one minute.

§ 37. The enormous force contained in the sunshine is not generally realized. If we express this in horse power per square yard, 10 calories is equivalent to nearly 8–10 (.821) of a horse power per square yard, or when the radiation amounts to as much as 12.8 calories, the solar energy which is being received, is equivalent to one horse power per square yard. An examination of the column shows that this often exceeds one horse power per square yard of surface perpendicular to the sun's rays.

§ 38. These observations have been carried on now for a number of years at this institution. They are the first, so far as is known, in this country. The instrument is read at noon on week days. The numerous blanks are due to the absence of the observer at outside observations.

§ 39. The column of frost or dew indicates the dates on which the frost or dew was observed. It does not denote that these were the only days. During the summer, it is probable that many days of dew have been overlooked, for the dew has time to evaporate before the observation at 7 o'clock is made. On nearly every morning, the reading of the terrestrial thermometer is lower than the dew point at the same time. If so, it may be certain that there has been dew or frost. If the radiation thermometer has been below 32°, it is frost; if above, dew. A comparison of the terrestrial radiation column and the dew point temperatures at 7 a. m. of the same day show a few such cases.

The summaries in tables 2, 3, and 4, show the number of days during the year on which frost occurs. The greater amount of moisture at Fort Collins over Cheyenne Wells is shown by the greater number of times that frost and dew were observed.

Table 5 gives the precipitation as observed at the Agricultural College by months. As before stated, the records previous to 1887 were scattered and lost, although the observations were taken for most of the months. The average of the different months is used as the normal precipitation, making the normal for the year 13.86 inches. It will be noticed, that during the last eleven years, six years have been above the normal, and one very much below.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.														Terrestrial Radiation	
	7 A. M.				7 P. M.				Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Instrument Reading	Radiation
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity								
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	31.7	25.8	14.2	47.6	27.7	23.3	14.2	56.6	14.2	52.1	34.0	27.5	30.7	6.5	25.0	2.5
2	22.0	18.2	8.4	55.4	23.6	17.3	-3.0	30.9	2.7	43.1	32.8	15.0	23.9	17.8	7.0	8.0
3	23.0	17.2	-1.0	34.9	19.8	15.6	-2.8	47.6	0.9	41 3	29.4	9.1	19.3	20.3	2.0	7.1
4	7.1	5.7	0.0	73.6	21.3	15.6	-8.3	25.9	-4.2	49.7	42.7	6.2	24.4	36.5	1.7	4.5
5	12.6	9.8	-0.3	56.6	32.3	24.3	5.2	31.2	2.5	43 9	46.2	11.1	28.7	35.1	3.8	7.3
6	18.4	16.0	9.6	68.6	35.7	27.0	8.5	31.7	9.0	50.2	47.3	15.8	31.5	31.5	10.4	5.4
7	14.2	13.3	10.6	86.6	23.1	19.9	12.5	63.4	11.6	75.0	54.9	13.7	34.3	41.2	7.8	5.9
8	14.0	12.0	6.0	70.2	46.6	32.2	1.2	15.3	3.6	42.7	64.0	12.2	38.1	51.8	5.9	6.3
9	14.4	13.7	11.7	89.6	33.1	25.0	6.4	31.9	9.0	60.8	53.3	14.1	33.7	39.2	9.3	4.8
10	16.1	14.9	11.7	83.1	21.1	17.8	9.3	60.0	10.5	71.5	44.0	* 16.0	30.0	28.0	7p.m. 11.4	4.6
11	15.7	14.1	9.7	77.3	28.2	23.1	12.0	50.4	10.9	63.9	48.1	13 0	30.6	35.1	7.1	5.9
12	22.8	21.4	18.7	83.7	29.8	25.6	17.8	60.6	18.2	72.1	47.7	20.4	34.0	27.3	16.2	4.2
13	13.0	12.7	11.8	95.3	29.8	24.7	14.5	52.2	13.2	73.8	42.6	13.2	27.9	29.4	6.7	6.5
14	24.1	23.8	23.5	96.6	22.1	20.9	18.5	85.8	21.0	91.2	34.0	23.8	28.9	10.2	24.0	-0.2
15	10.2	9.7	8.2	91.5	38.2	30.1	16.1	40.1	12.1	65.8	48.8	10.0	29.4	38.8	0.0	10.0
16	21.1	20.6	19.6	93.9	34.0	29.8	23.4	64.6	21.5	79.2	39.3	18.7	29.0	20.6	12.7	-6.0
17	23.0	18.9	8.6	53.4	26.0	20.8	8.1	46.5	8.4	50 0	42.6	* 22.6	32.6	20.0	17.4	5.2
18	11.1	8.9	5.8	80.3	20.0	15.6	1.9	45.4	3.9	62.8	54.7	6.7	30.7	48.0	2 7	4.0
19	11.0	10.1	7.1	85.1	24.7	19.1	3.7	40.2	5.4	62.7	54.8	9.3	32.1	45.5	5.9	3.4
20	13.2	11.7	7.2	77.0	36.1	25.8	-0.5	20.9	3.3	48.9	49.1	12.2	30.6	36.9	7.7	4.5
21	23.8	20.1	11.5	58.8	43.4	32.7	14.4	30.7	13 0	44.8	56.8	20.0	38.4	36.8	16.0	4.0
22	28.1	27.0	25.3	88.8	30.0	25.9	18 4	61.7	21.8	75.2	54.6	26.2	40.4	28.4	23.2	3.0
23	21.8	20.0	16.3	78.4	9.0	7.8	3.4	78.8	9.9	78.6	59.0	19.8	39.4	39.2	16.9	2.9
24	-4.1	-4.3	-5.1	94.0	-0.2	-1.1	-4.6	79.7	-4.9	86.9	9.3	-5.0	2.2	14.3	-5.8	0.8
25	-6.0	-6.2	-7.0	93.5	-4.7	-4.9	-5.7	93.9	-6.3	93.7	1.2	-7.0	-2.9	8.2	-8.2	1.2
26	-6.8	-6.8	-6.8	100.	-17.0	-17.0	-17.0	100.	-11.9	100.0	5.3	* -17.0	-5.9	22.3	7p.m. -23.2	6.2
27	-23.0	-23.0	-23.0	100.	-14.4	-14.8	-18.3	81.3	-20.7	90.6	9.0	-26.0	-8.5	35.0	-30.0	4.0
28	-14.3	-14.6	-16.5	86.0	-3.8	-3.8	-3.8	100.	-10.1	93.0	19.2	-19.2	0.0	38.4	-21.2	2.0
29	-4.2	-4.8	-7.9	81.8	13.2	12.2	9.1	84.6	0.6	83.2	37.0	-8.8	14.1	45.8	-11.0	2.2
30	9.2	9.2	9.2	100.	33.0	30.7	27.4	79.8	18.3	89.9	39.7	8.0	23.9	31.7	4.8	3.2
31	10.0	9.6	8.4	93.1	31.7	28.8	24.3	73.9	16 3	83.5	44.6	7.8	26.2	36.8	5.7	2.1
M	12.04	10.47	6.31	79.83	22.37	549.4	6.84	56.95	6.57	68.39	40.19	9.33	24.76	30.86	4.90	4.44

* Minimum temperatnre of day occurred between 7 a. m. and 7 p. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF JANUARY, 1897.

Barometer, Corrected for Temperature and Instrumental Errors.			PRECIPITATION				Direction of Wind.		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean.	Time of Beginning	Time of Ending	Total Am't Rain and Melted Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
					Ins.	Ins			Miles	C °	C °	C °	Cal	
24.788	24.902	24.8[illegible]	....	....	.....	....	n	n	2[illegible]0.7	......	......	......	......	......
2[illegible].083	25.054	25.069	....	....	.....	....	n	n w	297.4	31.2	11.2	20.0	12.33	......
25.01[illegible]	[illegible]	[illegible]	....	....	.....	....	[illegible]	[illegible]	[illegible]	......	......	......	......	......
25.058	25.016	25.037	....	....	.....	....	e	s	237.0	30.3	9.5	20.8	12.70	......
25.068	25.015	25.057	....	....	.....	....	n e	n	152.2	28.2	18.3	9.9	6.20	......
2[illegible].062	25.102	25.082	....	....	.....	....	w	w	106.6	......	......	......	......	......
25.161	25.140	25.150	....	....	.....	....	n w	w	83.6	38.4	19.8	18.6	12.18	Lt F
25.091	25.134	25.113	....	....	.....	....	n w	s w	130.1	42.7	20.3	22.4	14.95	Lt F
25.270	25.096	25.183	....	....	.....	....	n	w	131.4	36.6	18.1	18.5	11.96	......
25.168	25.119	25.143	....	....	.....	....	e	w	121.5	......	......	......	......	......
25.078	24.919	24.999	....	....	.....	....	w	n e	114.7	34.5	17.2	17.3	11.05	......
24.62[illegible]	2[illegible]	24.602	Nt.	Nt.	T	T	s e	n	148.3	26.1	11.8	14.3	8.66	......
24.7[illegible]	24.8[illegible]0	24.828	....	....	.....	....	n	s	142.3	33.7	14.5	19.2	12.10	F
24.9[illegible]	24.891	24.912	....	....	.....	....	n e	n	89.5	8.1	1.0	7.1	3.80	......
24.8[illegible]	24.714	24.783	8:20p.m	....	.....	....	0	n e	133.8	37.7	17.8	19.9	12.90	F
24.5[illegible]	24.580	24.549	....	....	T	...	n w	n w	439.7	......	......	......	......	F
25.[illegible]47	25.1[illegible]7	25.122	....	.....	......	....	n	s w	197.3	......	......	......	......	......
25.182	25.1[illegible]	25.141	.. .	..	......	....	w	s	132.3	37.8	19.2	18.6	12.13	F
24.954	24.873	24.914	.. .	.	......	....	n w	s	150.0	23.5	13.7	9.8	5.92	F
24.910	24.947	24.928	.	. ..	......	....	n e	w	174.5	35.9	17.2	18.7	12.01	F
24.875	24.9[illegible]5	24.895		..	......	....	n	n w	230.1	9.1	4.8	4.3	2.37	......
25.155	25.078	25.117	.	.. .	......	....	s	n w	110.9	34.5	16.0	18.5	11.76	......
24.925	25.084	25.004	..	.. .	......	....	s e	s e	222.7	34.4	17.2	17.2	10.98	......
25.162	24.900	25.032	Nt.	Nt	T	....	s e	n e	115.6	......	......	......	......	......
25.048	25.034	25.041	9:30 a m	.. ...	.14	....	s	n e	126.6	......	......	......	......	......
24.994	25.008	25.001	....	7.40 a m	.04	....	s e	n n w	116.5	31.4	2.1	29.3	17.48	......
25.019	25.108	25.063	.	....	......	....	n w	n w	92.4	28.7	1.6	27.1	15.96	F
25.140	25.096	25.118	....	....	......	....	.0	n w	80.5	31.4	5.4	26.0	15.70	F
24.905	24.756	24.831	....	....	......	....	n w	n w	70.6	36.1	11.8	24.3	15.31	F
24.764	24.927	25.845	....	....	......	....	n w	s	141.7	......	......	......	......	F
25.008	25.055	25.032	....	....	......	....	w	n e	91.9	......	......	......	......	F
24.988	24.982	24.985	....	....	.18	....	n	n w	163.2	30.97	12.79	18.18	11.35	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point.	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point.	Relative Humidity							Instrument Reading	Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F °	Per Cent	F °	F °	F °	F °	F °	F °
1	11.9	11.5	10.4	93.6	29.6	27.2	23.3	76.9	16.8	86.2	46.9	10.1	28.8	36.2	8.4	2.3
2	22.8	21.5	19.0	84.9	33.6	29.7	23.8	66.7	21.4	75.8	55.1	22.9	39.0	32.2	18.8	4.1
3	23.9	21.9	18.0	77.4	33.3	28.2	19.6	56.2	18.8	66.8	46.5	22.3	34.3	24.0	17.1	5.2
4	11.2	11.0	10.4	96.7	32.1	25.6	12.3	43.2	11.4	70.0	44.8	10.8	27.8	34.0	8.0	2.8
5	25.0	22.9	18.9	77.0	34.3	28.8	19.6	54.3	19.2	65.6	38.8	19.4	29.1	19.4	16.8	2.6
6	26.7	24.2	19.6	74.0	33.8	31.2	27.6	77.8	23.6	75.9	47.9	19.8	33.8	28.1	15.9	3.9
7	45.8	25.3	24.5	94.6	26.0	24.6	22.1	85.0	23.3	89.8	43.3	24.5	33.9	18.8	22.0	2.5
8	14.0	13 7	12.9	95.5	26.8	24.7	20.9	78.1	16.9	86.8	40.2	11.8	26.0	28.4	8.9	2.9
9	16.2	15.6	14.0	91.6	33.9	30.2	24.7	68.7	19.4	80.2	44.1	14.2	29.2	29.9	11.2	3.0
10	20.8	20.8	20.8	100.	20.2	19.9	19.3	96.2	20.0	98.1	29.4	20.0	24.7	9.4	16.7	3.3
11	20.0	19.6	18.8	95.0	27.2	25.3	22.0	80.4	20.4	87.7	43.7	16.0	29.8	27.7	11.2	4.8
12	24.7	22.1	16.9	71.5	30.8	22.9	2.4	29.4	9.7	50.4	50.8	21.9	36.4	28.9	17.0	4.9
13	10.4	9.9	8.4	91.5	19.2	14.0	-4.2	34.4	2.1	63.0	33.2	9.2	21.2	24.0	6.1	3.1
14	2.9	2.2	-0.7	84.4	24.7	18.7	1.3	36.1	0.3	60.2	37.0	0.1	18.5	36.9	-4.2	4.3
15	25.8	20.8	8.8	48.2	45.0	32.8	10.7	21.6	9.7	36.4	47.9	19.5	33.7	28.4	12.5	7.0
16	41.3	30.9	11.5	29.4	33.1	27.1	16.1	48.6	13.8	39.0	55.0	34.0	44.5	21.0	25.8	8.2
17	21.8	21.8	21.8	100.0	22.5	22.0	21.0	94.2	21.4	97.1	30.7	21.0	25.9	9.7	21.0	0.0
18	22.2	21.3	19.4	89.1	23.0	20.2	14.1	67.8	16.8	78.5	29.0	17.1	23.0	11.9	14.0	3.1
19	1.8	1.8	1.8	100.	37.8	28.0	7.2	27.5	4.5	63.7	39.7	4.9	22.3	34.8	-0.2	5.1
20	12.0	11.4	9.7	90.4	20.1	19.4	18.0	91.2	13.8	90.8	40.8	9.7*	25.3	31.1	3.7	6.0
21	17.2	17.0	16.5	97.3	12.0	12.0	12.0	100.	14.3	98.7	29.4	14.4	21.9	15.0	9.2	5.2
22	3.4	3.4	3.4	100.	23.8	17.8	-0.5	34.6	1.4	67.3	31.2	0.3	15.7	30.9	-3.7	4.0
23	-3.2	-3.8	6.8	82.6	24.2	21.3	15.2	67.8	4.2	75.2	34.6	-5.3	14.7	39.9	-9.9	4.6
24	5.3	5.2	4.8	97.9	26.0	21.2	10.0	50.5	7.4	74.2	34.9	5.0	19.9	29.9	-0.3	5.3
25	15.4	15.1	14.3	95.7	24.9	22 0	16.1	68.5	15.2	82.1	37.2	12.9	25.1	24.3	8.0	4.9
26	13.8	13.3	11.9	92.5	18.8	18.0	16.1	89.5	14.0	91.0	29.9	11.0	20.4	18.9	5.9	5.1
27	15.1	14.4	12.5	89.8	42.6	32.1	13.7	30.8	13.1	60.3	59.5	7.8	33.7	51.7	5.9	1.9
28	25.9	23.4	18.7	73.5	27.8	26.8	25.2	89.7	22.0	81.6	44.0	22.9	33.4	21.1	19.2	3.7
M	16.93	15.65	12.86	86.22	28.11	23.99	15.34	63.17	14.10	74.69	40.90	14.24	27.57	26.66	10.18	4.06

* Minimum temperature of day occurred between 7 a. m. and 7 p. m.

° Maximum temperature of day occurred between 7 p. m. and 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF FEBRUARY, 1897.

Barometer, Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'ltd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C°	C°	C°	Cal.	
25.127	25.036	25.081	....	Nt.	......	....	w	w	119.0	35.9	16.6	19.3	12.37	F
24.903	24.808	24.856	Nt.	....	......	....	w	n w	170.1	......	......	......	......	F
24.754	24.812	24.783	....	....	.02	....	s e	n	171.1	......	......	......	......	Lt Sn
24.879	24.753	24.816	....	....	......	....	0	n e	132.5	34.0	15.2	18.8	11.90	F
24.673	24.600	24.636	....	....	......	....	e	0	99.4	6.5	3.5	3.0	1.63	......
24.632	24.826	24.729	5:30p.m	Nt.	T	0.7	w	n e	152.1	22.5	12.3	10.2	6.10	......
25.007	24.984	24.996	....	....	.04	....	n e	s w	131.7	......	......	......	......	Sn
24.902	24.773	24.837	....	....	......	...	s e	s w	74.2	......	......	......	......	F
24.795	24.881	24.838	6:45p.m	12 m.	T	...	n w	n e	122.7	35.0	16.1	18.9	22.05	F
24.963	24.908	24.936	Nt.	....	.02	....	s e	w	79.6	8.6	1.1	7.5	4.08	Sn
24.782	24.694	24.738	....	....	......	....	e	n	98.4	13.4	4.1	9.3	5.21	F
24.508	24.524	24.581	12:10pm	....	T	....	s w	n w	370.6	38.8	20.3	18.5	12.16	F
24.726	24.845	24.785	....	....	......	....	s e	w	151.5	32.2	11.1	21.1	13.06	Lt F
24.823	24.770	24.797	....	....	......	....	n	n w	280.0	......	......	......	....	Lt F
24.737	24.669	24.706	....	....	......	....	s	s e	407.1	......	......	......	....	......
24.613	24.654	24.733	....	....	.....	2¾	s e	s w	367.1	39.7	22.3	17.5	11.63	......
24.874	24.996	24.035	Nt.	1:30p.m	.30	1¼	0	n w	70.0	25.1	8.2	16.9	10.05	Sn
24.942	24.916	24.929	Nt.	! 10 a.m	.07	1	n	e	67.3	....	....	......	......	......
24.715	24.613	24.661	Nt.	Nt.	T	....	n	w	216.7	32.2	14.3	17.9	11.21	......
24.696	24.675	24.683	2:30p.m	....	T	....	n w	w	133.0	......	......	......	......	......
24.651	24.704	24.677	Nt.	10 a. m.	.09	1¼	s e	n w	95.0	.....	......	......	......	Sn
24.794	24.926	24.860	....	....	......	....	s w	w	165.0	42.2	15.5	26.7	19.47	F
[illegible]	[illegible]	[illegible]	...	....	......	....	w	w	144.9	38.6	12.9	25.7	16.42	Lt F
[illegible]	25.022	[illegible]	...	......	......	....	n w	s w	175.5	Cl'dy	......	......	......	Lt F
[illegible]	[illegible]	[illegible]	...	......	......	....	s w	n e	172.3	27.1	10.2	17.3	10.47	......
25.310	25.214	25.262	...	......	T	....	0	n	169.1	35.7	11.8	23.9	15.03	Lt Sn
[illegible]	24.943	24.989	.....	..	. .	.	n w	s w	175.6	33.1	14.5	18.6	11.70	F
24.994	24.941	24.967	.	.	.....	....	n w	w	111.1	....	......	......	......	......
24.866	24.845	24.853	....	....	.54	7	......	......	165.1	29.47	12.35	17.12	10.86	.....

! Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY.																		Terrestrial Radiation	
	7 A. M				7 P. M.															
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F° *	F°	F°	F° *	F.
1	21.7	24.1	23.1	9 .3	21.8	21.8	21.8	100.0	22.4	96.6	21.9	21.1	23.0	3.8	21.7	-0.6
2	21.1	20.8	20.2	96.3	27.2	25.3	22.0	80.4	21.1	88.4	36.1	18.9	27.5	17.2	16.1	2.8
3	25.8	24.4	21.9	84.9	31.1	29.1	26.1	81.4	24.0	83.1	40.1	20.0	30.0	20.1	13.7	6.3
4	22.2	21.8	21.0	95.2	35.8	27.8	12.1	37.1	16.6	66.2	43.0	17.3	30.2	25.7	14.0	3.3
5	26 2	24.0	19.9	76.7	34.3	28.1	17.2	48.7	18.5	62.7	46.9	21.8	34.3	25.1	17.0	4.8
6	24.2	23.8	23.1	95.5	32.3	30.2	27.2	81.1	25.2	88.3	42.6	20.7	31.7	21.9	18.7	2.0
7	25.1	25.1	25.1	100.0	42.1	32.1	15.1	33.1	20.1	66.5	54.0	24.0	39.0	30.0	24.5	-0.5
8	33.3	29.8	14.5	37.4	34.7	30.2	23.4	62.8	18.9	50.1	49.1	33.2	41.1	15.9	26.0	7.2
9	22.5	21.9	20.8	93.0	33.6	25.1	5.1	29.6	13.0	61.3	43.9	20.0	32.0	23.9	16.2	3.8
10	21.2	20.1	17.8	86.6	37.0	31.3	22.7	55.9	20.2	71.3	50.7	15.0	32.8	35.7	12.0	3.0
11	25.9	20.0	4.3	39.4	28.6	20.9	-1.2	27.0	1.6	33.2	37.1	22.5	29.8	14.6	17.0	5.5
12	15.4	15.2	14.7	97.1	19.9	18.2	14.3	78.6	14.5	87.8	23.9	15.0	19.5	8.9	14.2	0.8
13	9.2	9.2	9.2	100.0	14.6	12.9	8.1	75.0	8.6	87.5	27.0	3.7	15.3	23.3	-0.9	4.6
14	12.2	11.8	10.7	93.6	26.6	22.9	15.4	62.1	13.1	77.9	39.3	7.1	23.2	32.2	3.2	3.9
15	20.7	19.7	17.5	87.7	31.0	26.3	17.8	57.1	17.6	72.4	47.4	14.4	30.9	33.0	10.9	3.5
16	24.6	23.9	22.7	92.2	43.0	34.4	22.0	43.0	22.4	67.6	52.0	17.6	34.8	34.4	13.2	4.4
17	38.2	32.9	25.5	60.2	42.5	33.3	19.1	38·6	22.3	49.4	58.7	31.9	45.3	26.8	25.9	6.0
18	32.8	29 2	23.7	68.6	44.2	34.1	18.5	35.4	21.1	52.0	60.3	24.2	42.3	36.1	18.8	5.4
19	34.1	29.1	20.9	58.0	31.1	23.1	2.4	29.1	11.6	43.5	47.6	23.0	35.3	24.6	18.8	4.2
20	22.1	19.0	11.5	63.5	29.0	28.1	26.7	91.1	9.1	77.3	40.1	15.6	27.8	24.5	11.0	4.6
21	25.4	25.4	25.4	100.0	21.1	20.9	20.5	97.6	23.0	98.8	30.6	24.7	27.7	5.9	* 20.7	4.0
22	16.8	16.8	16.8	100.0	15.8	15.2	13.6	91.4	15.2	95.7	32.3	* 15.4	23.8	16.9	11.0	4.4
23	5.1	5.1	5.1	100.0	19.8	17.9	13.3	76.1	9.2	88.1	38.2	-7.0	15.6	45.2	-11.8	4.8
24	18.7	17.4	14.3	83.1	30.9	26.8	19.6	62.5	16.9	72.8	42.[illegible]	6.3	24.6	36.6	1.0	5.3
25	29.3	26.9	23.0	76.7	38.1	34.1	28.9	69.8	26.0	73.2	53.6	19.4	36.5	34.2	14.2	5.2
26	35.5	32.3	28.0	74.0	48.9	41.2	33.0	54.4	30.5	64.2	64.1	27.2	45.7	36.9	23.9	3.3
27	36.1	33.6	30.4	80.0	45.9	36.3	23.1	40.4	26.7	60.2	65.0	29.7	47.3	35.3	25.9	3.8
28	36.9	36.1	35.2	93.6	47.6	42.1	36.6	66.4	35.9	80.0	65.3	28.9	47.1	36.4	23.9	5.0
29	34.0	32.0	29.3	82.8	45 8	40.8	35.7	68.2	32.5	75.5	60.0	29.4	44.7	30.6	23.4	6.0
30	30.8	30 8	30.8	100.0	27.1	24.9	20.9	77.3	25.9	88.7	35.4	30.0	32.7	5.4	30.0	0.0
31	29.2	27.8	25.6	80.2	30.9	26.1	17.3	56.1	21.4	71.1	37.3	24.7	31.0	12.6	24.0	0.7
M	25.30	23 55	20.39	83.73	32.65	27.79	19 30	51.53	19.84	72.63	44.82	19.86	32.34	24.96	16.07	3.79

* Minimum temperature of day occurred between 7 a. m. and 7 p. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF MARCH, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Tot. Am't Rain and M'l'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C°	C°	C°	Cal.	
[illegible]	[illegible]	[illegible]		[illegible]	.01	....	s e	s e	166.8	Cl'dy	......	......	......	F
[illegible]	[illegible]	[illegible]	Nt.	Nt	.17	2½	0	w	125.5	31.8	11.2	20.6	12.73	Sn
[illegible]	[illegible]	[illegible]	7:30 a.m	....	T	....	s	e	145.9	23.6	8.5	15.1	8.95	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	T		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	F
[illegible]	[illegible]	[illegible]		....	......	....	s w	w	[illegible]	......	......	......	......	Lt. F
[illegible]	[illegible]	[illegible]		....	......	....	n	e	103.6	......	......	......	......	F
[illegible]	[illegible]	[illegible]			...	....	s e	w	287.5	......	......	......	......	F, g
[illegible]	[illegible]	[illegible]		[illegible]	......	....	s e	n e	259.8	36.6	18.5	18.1	11.71	
[illegible]	[illegible]	[illegible]		...	.01	....	s e	s w	291.6	35.0	15.6	19.4	12.34	
[illegible]	[illegible]	[illegible]			......	....	s	w	385.0	37.0	18.3	18.7	12.11	
[illegible]	[illegible]	[illegible]	Nt.	.	......	....	n w	s w	431.4	33.5	13.3	20.2	12.67	
[illegible]	[illegible]	[illegible]	Nt.	[illegible] p. m.	.06	½	e	n	245.0	18.0	3.1	14.9	8.46	Sn
[illegible]	[illegible]	[illegible]	....	Nt	.01	....	s	s	149.0	29.6	6.7	22.9	13.80	Sn
[illegible]	[illegible]	[illegible]	..	.....	......	....	0	w	121.0	......	......	......	......	F
[illegible]	[illegible]	[illegible]	.	. ..	......	....	0	n w	131.4	36.3	17.2	19.1	12.29	F
24.945	[illegible]	[illegible]		.	......	....	n	w	185.4	33.5	18.5	15.0	9.59	F
24.790	[illegible]	[illegible]	..	..	......	...	s e	w	[illegible]	......	......	......	......	
[illegible]	[illegible]	[illegible]		.	......	....	n e	w	212.1	42.6	25.1	17.5	11.89	Lt. F
[illegible]	[illegible]	24.599	12:10pm	....	T	....	n w	n w	256.9	17.3	10.7	6.6	3.85	
24.662	24.606	24.634	5:20 p m	....	.02	....	0	e	146.8	23.8	11.1	12.7	7.60	
24.703	24.940	24.821	....	....	.80	11	n e	e	141.3	......	......	......	......	Sn
25.066	25.073	25.070	....	Day	.08	1	n w	s w	106.2	47.3	19.2	28.1	19.02	Sn
24.975	24.996	24.985	....	....	......	....	w	s w	96.8	45.8	18.5	27.3	18.32	F
24.925	24.961	24.913	....	.....	......	....	e	w	92.9	36.0	17.6	18.4	11.84	F
25.001	24.954	24.978	.....	......	......	....	n w	s w	160.1	46.0	22.8	23.2	15.21	
24.928	24.868	24.898	.....	......	......	....	s w	s	151.0	47.1	26.7	20.4	14.19	
24.886	24.823	24.854	......	......	......		n w	s w	231.7	42.5	25.7	16.8	11.43	F
24.812	24.522	24.667	....	....	......	....	e	n	170.8	......	......	......	......	Hv F
24.510	24.459	24.485	6:30 p m	....	T	sm	n	n w	265.6	44.4	25.7	18.7	12.82	F
24.432	24.674	24.553	....	10 a .m.	.99	7	n w	n w	854.0	25.6	10.5	15.1	9.08	Sn
24.718	24.965	24.841	....	....	......	....	n w	n	553.5	33.5	13.7	19.8	12.44	
24.812	24.799	24.806	....	....	2.15	22.	......	......	227.1	34.64	16.20	18.44	12.26	......

† Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.														Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dail Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	37.2	28.7	12.5	35.6	36.2	32.2	26.6	68.3	19.5	51.9	48.6	28.7	38.6	19.9	23.0	5.7
2	29.2	29.2	29.2	100.	29.0	27.1	24.1	81.2	26.7	90.6	34.4	28.5	31.5	5.9	28.1	0.4
3	26.2	24.2	20.5	78.8	39.7	31.4	17.7	40.8	19.1	59.8	43.9	20.0	31.9	23.9	12.9	7.1
4	32.0	31.1	29.8	91.7	42.5	32.8	17.1	35.1	23.4	63.4	52.1	22.7	37.4	29.4	19.9	2.8
5	36.0	33.9	31.2	83.0	40.2	38.9	37.6	90.5	34.4	86.8	51.0	27.2	39.1	23.8	23.2	4.0
6	39.9	34.1	26.3	58.2	36.1	35.8	35.4	97.5	30.9	77.8	51.9	32.9	42.4	19.0	27.0	5.9
7	32 6	32.4	32.1	98.2	32.6	31.8	30.7	92.8	31.4	95.5	45.0	31.4	38.2	13.6	30.3	1.1
8	32.3	31.9	31.3	96.3	34.1	31.9	28.9	81.2	30.1	88.8	46.1	20.1	33.1	26.0	16.8	3.3
9	32.8	31.7	30.2	90.2	42.9	35.0	24.1	47.3	27.1	68.7	50 8	22.8	36.8	28.0	20.0	2.8
10	41.2	37.3	32.8	72.6	55.9	41.1	22.2	27.0	27.5	49.8	66.7	33.4	50.1	33.3	28.0	5.4
11	47 6	37.7	24.9	40.8	38.4	33.2	26.1	61.1	25.5	51.0	55.0	35.6	45.3	19.4	31.7	3.9
12	41.3	36.1	29.7	63.7	40.7	34.2	25.4	54.1	27.6	58.9	54.5	36.9	45.7	17.6	34.0	2.9
13	33.0	30.9	28.0	81.5	43.1	33.8	19 7	38.8	23.8	60.1	58.1	23.0	40.5	35.1	18.3	4.7
14	42.2	36.8	30.3	63.1	49.7	37.9	21.8	33.4	26.1	48.3	65.8	24.9	45.4	40.9	20.2	4.7
15	40.2	38.9	37.6	90.5	50.3	40.1	28.0	42.3	32.8	66.4	57.3	34.6	45.9	22.7	33.7	0.9
16	45.7	40.9	36.0	69.4	55.0	43.2	30.5	39.4	33.2	54.4	69.8	33.8	51.8	36.0	28.9	4.9
17	50.0	42.1	33.9	54.1	61.6	42.4	15.9	16.8	24.9	35.4	73.9	31.1	52.5	42.8	26.7	4.4
18	58.6	45.1	31.3	35.7	56.6	43.0	27.6	33.1	29.5	34.4	73.7	38.3	56.0	35.4	33.0	5 3
19	39.8	35.8	31.0	71.0	50.0	40.9	30.7	47.7	30.8	59 4	61 5	35.3	48.4	26.2	31.1	4.2
20	44.9	40.9	36.9	74.0	56.2	40.0	17.1	21.4	27.0	47.7	70.5	37.4	54.0	33.1	34.0	3.4
21	51.2	39.8	25.8	37.2	48.2	35.8	16.7	28.3	21.3	32.7	60.1	38.6	49.3	21.5	29.9	8.7
22	42.0	38.1	33.8	73.2	45.0	37.5	28.3	52.0	31.0	62.6	61.6	33.2	47.4	28.4	28.3	4.9
23	43.7	38.2	31.9	63.7	51.0	41.3	30.5	45.5	31.2	54.6	56.8	39.0	47.9	17.8	37.3	1.7
24	47.2	42.2	37.3	69.1	46.6	44.8	43.3	88.6	40.3	78.9	63.1	43.6	53.4	19.5	39.9	3.7
25	47.1	45.1	43.4	87.4	53.0	40.4	21.8	33.5	34.1	60.4	73.0	30.8	51.9	42.2	26.2	4.6
26	61.7	46.9	32.5	33.4	59.8	43.1	22.7	24.0	27.6	28.7	77.2	35.4	56.3	41 8	30.7	4.7
27	55.0	45.9	37.6	52.1	57.7	48.2	40.2	52.4	38.9	52.3	73.6	39.5	56.5	34.1	35.2	4.3
28	40.9	37.1	32.7	73.1	48.9	40.9	32.2	52.7	32.5	62.9	60.1	38.0	49.1	22.1	37.6	0.4
29	41.8	38.1	34.0	74.3	46.9	44.8	43.0	86.7	38.5	80.5	61.1	32.0	46.5	29.1	26.4	5.6
30	44.7	42.5	40.5	85.5	55.8	45.3	35.2	46.2	37.8	65.8	68.5	31.8	50.2	36.7	28.1	3.7
M	41.93	37.12	31.5	69.91	46.79	38.2	27.47	51.99	29.48	60.95	59.52	32.02	45.77	27.51	28.01	4.00

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF APRIL, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.918	24.886	24.902	....	..	....	....	n w	s e	236.0	37.0	19.0	18.0	11.69	....
24.828	24.871	24.849	Nt.	† 3 p. m.	0.36	1¾	e	n w	189.4	29.1	11.5	17.6	10.78	Sn
24.894	24.894	24.894	....	....	....	...	n	w	153.7	42.5	19.6	22.9	15.24	....
24.951	24.965	24.958	....	....	....	....	s e	w	296.2	....	....	....	....	Hv. F
24.978	24.922	24.950	3:30p.m.	....	.04	....	n	s w	164.4	....	....	....	....	F
25.019	24.881	24.950	Nt.	Nt.	.11	....	n w	e	210.1	....	....	....	....	....
24.876	25.144	25.010	5 p. m.	Nt.	.34	2	n	n	204.4	40.8	19.8	21.0	13.88	Sn
25.165	25.199	25.182	....	† 5 p.m	T	....	0	n e	146.2	19.0	11.0	8.0	4.70	....
25.186	25.066	25.126	....	3 p.m.	T	....	0	n w	220.9	25.5	14.2	11.3	6.89	Hv. F
25.041	24.814	24.928	....	....	....	....	s	w	300.3	43.0	26.8	16.2	11.09	F
24.680	24.872	24.776	....	....	....	....	w	n	490.1	....	....	....	....	....
24.984	25.117	25.050	..	....	....	....	n w	n w	378.0	....	....	....	....	....
25.257	25.109	25.182	....	....	....	....	s	s w	136.3	....	....	....	....	F
25.097	25.070	25.084	...	....	.	.	n w	n w	287.4	48.0	30.2	17.8	12.59	F
25.241	25.131	25.186	5:30p.m.	Nt.	.16	T	s w	n	115.0	42.5	23.8	18.7	12.63	....
25.157	25.117	25.137	....	....	....	....	0	w	158.9	44.9	28.6	16.3	11.32	....
25.127	24.936	25.031	...	...		..	n	w	185.3	47.5	31.7	15.8	11.22	....
24.982	25.084	25.033		..	.	..	n w	n e	228.1	....	....	....	....	....
25.189	24.999	25.094	....	....	.	....	s e	n w	236.8	....	....	....	....	....
24.921	24.767	24.844	....		...	.	n e	w	262.6	....	....	....	....	....
24.779	24.832	24.806	...	..	....	....	n e	n w	350.9	39.0	24.4	14.6	9.75	....
24.871	24.864	24.867	5:20p.m.	....	T	....	e	n w	275.2	35.7	21.7	14.0	9.14	....
25.02[illegible]	24.99[illegible]	25.01[illegible]	....	.	....	....	n w	n w	132.6	39.3	23.0	16.3	10.84	....
25.073	25.124	25.099	5:30p.m.	....	.02	....	s e	s w	128.4	....	....	....	....	....
25.277	25.130	25.203	Nt.	Nt.	T	....	s e	s	188.8	....	....	....	....	....
25.142	24.852	24.997	....	....	....	....	n w	s w	184.9	40.2	24.0	16.2	10.86	....
24.701	24.652	24.676	p. m.	p. m.	T	....	0	n	341.6	....	....	....	....	....
25.117	25.070	25.094	....	....	....	....	e	s e	217.7	40.3	23.5	16.8	11.24	....
25.056	25.195	25.126	3 p. m.	....	.36	..	0	n	133.5	....	....	....	....	F
25.236	25.088	25.162	Nt.	Nt.	T	....	0	s	160.6	44.2	28.2	16.0	11.06	....
25.025	24.988	25.006	....	....	1.39	4.	....	....	223.8	38.74	22.41	16.32	10.88	....

† Used to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY															
	7 A. M.				7 P. M.										Terrestrial Radiation	
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Instrument Reading	Radiation
	F°	F°	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent.	F°	F°	F°	F°	F°	F°
1	53.1	46.8	41.5	65.0	57.0	45.8	35.1	44.1	38.3	54.5	76.6	33.1	54.8	43.5	28.5	4.6
2	65.0	50.8	39.2	38.8	57.1	46.4	36.6	46.5	37.9	42.7	76.5	39.8	58.2	36.7	32.0	7.8
3	52.1	46.9	42.6	70.4	57.8	45.3	32.9	38.9	37.7	54.6	73.6	38.6	56.1	35.0	33.0	5.6
4	52.0	46.9	42.7	70.9	63.1	50.0	39.2	41.3	41.0	56.1	74.7	38.8	56.7	35.9	32.9	5.9
5	57.2	50.7	45.9	66.0	59.1	49.5	41.8	52.9	43.8	59.5	73.0	42.5	57.8	30.5	38.0	4.5
6	55.1	49.1	44.5	67.4	59.5	48.9	40.1	48.8	42.3	58.1	75.5	36.0	55.7	39.5	31.0	5.0
7	57.2	51.0	46.5	67.5	58.9	50.8	44.8	59.5	45.7	63.5	75.7	41.8	58.8	33.9	36.2	5.6
8	60.2	47.9	36.9	42.0	55.9	43.7	30.7	38.5	33.8	40.2	70.1	43.0	56.5	27.1	38.7	4.3
9	50.1	42.2	34.1	54.2	57.7	44.8	31.5	37.2	32.8	45.7	70.2	31.6	50.9	38.6	27.7	3.9
10	53.2	43.6	33.9	48.2	46.2	44.2	42.4	87.2	38.1	67.7	63.9	44.7	54.3	19.2	37.7	7.0
11	45.7	44.8	43.2	88.0	52.0	45.2	39.1	61.6	41.2	74.8	62.2	42.7	52.5	19.5	41.6	1.1
12	58.1	48.1	39.6	50.8	59.0	49.2	41.2	51.9	40.4	51.1	71.0	39.5	55.2	31.5	33.1	6.4
13	56.6	48.2	41.3	56.6	54.2	46.8	40.6	59.8	40.9	58.2	71.0	41.2	56.1	29.8	35.9	5.3
14	47.8	42.3	36.9	66.6	58.1	48.9	41.4	53.9	39.2	60.3	75.8	34.3	55.1	41.5	27.8	6.5
15	58.2	49.7	43.1	57.1	65.3	52.0	41.8	42.5	42.4	49.8	77.7	38.6	58.1	39.1	34.0	4.6
16	58.8	51.9	47.1	64.9	59.2	52.8	48.5	67.5	47.8	66.2	79.1	40.6	59.9	38.5	34.8	5.8
17	57.0	51.9	48.3	72.9	70.8	53.9	41.2	34.5	44.8	53.7	82.0	38.7	60.3	43.3	33.1	5.6
18	59.4	53.8	50.2	71.4	63.1	52.6	45.0	51.8	47.6	61.6	80.0	46.0	63.0	34.0	39.9	6.1
19	60.6	53.9	49.5	66.8	58.5	54.7	52.4	80.0	50.9	73.4	76.2	42.8	59.5	33.4	37.0	5.8
20	52.2	52.0	51.9	98.8	60.8	56.2	53.5	76.8	52.7	87.8	71.9	* 51.8	61.9	20.1	50.8	1.0
21	54.7	53.3	52.4	92.1	58.9	55.3	53.1	81.0	52.8	86.5	68.9	51.6	60.2	17.3	48.9	2.7
22	59.3	54.5	51.4	75.2	61.0	58.4	53.7	76.9	52.5	76.1	74.3	51.3	62.8	23.0	44.8	6.5
23	56.0	50.8	47.8	72.0	61.1	54.2	49.8	67.8	48.8	69.9	73.1	‖46.4	59.8	26.7	39.8	6.6
24	55.6	49.2	50.3	65.7	60.1	55.0	51.8	74.1	51.1	69.9	71.8	48.7	60.2	23.1	41.7	7.0
25	60.0	54.1	50.3	70.2	61.2	54.4	50.1	66.6	50.2	68.4	81.1	45.3	63.2	35.8	38.4	6.9
26	63.2	55.1	50.1	61.9	65.0	52.8	43.9	46.5	47.0	54.2	82.3	43.2	62.8	39.1	37.0	6.2
27	53.5	50.0	47.5	80.2	51.2	47.0	43.6	75.7	45.5	77.9	‖53.0	52.0	52.5	1.0	48.5	3.5
28	51.8	48.8	46.5	82.6	62.0	54.8	50.2	65.2	48.4	73.9	78.0	38.5	58.2	39.5	33.6	5.5
29	64.0	55.6	50.3	61.0	66.0	55.3	48.3	52.9	49.3	57.0	66.0	47.8	56.9	18.2	40.4	7.4
30	50.2	47.0	44.8	82.2	62.0	53.6	47.9	60.0	46.3	71.1	78.0	44.5	61.3	33.5	37.1	7.4
31	63.0	55.8	49.9	62.2	62.5	57.4	54.5	76.0	52.2	69.1	77.0	47.2	62.1	29.8	43.0	4.2
M	56.19	49.89	45.17	67.39	59.49	50.96	44.09	58.64	44.63	63.02	73.55	42.66	58.11	30.89	37.30	5.36

‖ Minimum temperature of 23 from thermograph.
‖ Maximum temperature of 27 before 7 a. m.
* On the 20th the lowest temperature was after the 7 a. m. observation.—51°

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF MAY, 1897.

Barometer Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and Mlt'd Snow	Av'g Depth of Snow	7 A. M.	7. P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C	C	C	Cal.	
25.006	24.842	24.924	....	....	......	....	0	w	133.6	......	......	......	......	......
24.940	25.031	24.985	....	....	......	....	n w	n w	220.9	......	......	......	......	......
25.088	25.034	25.061	....	....	......	....	n w	s	262.5	49.0	32.2	16.8	12.02	F
25.076	25.035	25.056	....	....	......	....	n w	s	173.5	......	......	......	......	......
25.128	25.109	25.118	....	....	......	....	n e	s	150.7	39.1	27.8	11.3	7.65	D
25.096	24.950	25.023	....	....	......	....	0	e	151.5	47.6	32.3	15.3	10.89	......
24.947	24.850	24.899	4:45p.m	....	T	....	0	n	203.8	49.0	32.8	16.2	11.61	D
24.927	25.080	25.003	....	....	......	....	n w	s	281.8	......	......	......	......	......
25.167	24.946	25.057	6:50p.m	....	......	....	n w	s w	170.8	......	......	......	......	......
25.049	25.047	25.048	Nt.	Nt.	T	....	n	n	139.7	......	......	......	......	......
25.062	24.953	25.007	†	1 p.m.	.10	....	s	s w	159.0	......	......	......	......	......
24.986	24.976	24.981	....	....	......	....	n e	s	199.4	42.5	28.2	14.3	9.82	......
25.024	25.073	25.049	....	....	......	....	0	n w	149.4	48.3	31.6	16.7	11.89	......
25.083	25.000	25.041	....	....	......	....	n w	n w	126.0	......	......	......	......	Lt. F
25.076	25.031	25.054	1:30p.m	....	.01	....	0	n e	119.8	36.6	27.0	9.6	6.42	D
25.065	25.080	25.072	†	1:30p.m	T	....	s	s w	155.6	......	......	......	......	D
25.087	24.983	25.035	7:10p.m	....	T	....	n	n w	131.6	52.6	37.0	15.6	11.53	Hv.D
25.063	25.072	25.068	4 p.m.	....	.03	....	n w	n	156.9	......	......	......	......	D
25.133	25.111	25.122	4 p.m.	5:40p.m	.19	....	s e	n w	183.6	49.6	34.5	15.1	10.92	D
25.171	25.049	25.110	Nt.	....	1.28	....	n w	s	128.7	47.0	29.1	17.9	12.56	......
24.981	24.839	24.910	† 8p.m.	10:40am	.03	....	s w	n e	......	26.7	20.9	5.8	3.65	......
24.983	24.914	24.948	3:30p.m	5:30p.m	.03	....	s w	s	*295.3	46.4	30.8	15.6	10.99	......
25.142	25.063	25.103	†	....	......	....	s w	s w	126.2	......	......	......	......	......
25.113	24.928	25.020	† 3:45p.m	5 p.m.	.01	....	n e	n w	172.8	49.1	32.2	16.9	12.09	......
24.948	24.913	24.931	Nt.	Nt.	T	....	n w	n	126.5	......	......	......	......	......
24.963	24.929	24.946	8 p. m	....	.11	....	e	n w	209.8	54.3	38.4	15.9	11.89	D
25.303	25.397	25.350	....	....	.08	....	n e	n w	112.4	12.2	9.0	3.2	1.82	......
25.334	25.157	25.245	1:30p.m	5 p.m.	.02	....	s e	s w	138.0	44.1	28.4	15.7	10.86	......
25.151	25.107	25.129	....	....	......	....	n	s	108.3	32.0	26.9	5.1	3.35	.....
25.154	24.928	25.041	† 3 p. m	5 p.m.	.04	....	e	s w	148.3	32.0	26.9	5.1	3.35	......
24.787	24.728	24.758	† 9:30a.m	4 p.m.	.13	....	s w	w	132.0	......	......	......	......	......
25.066	25.005	25.035	....	....	2.06	....	....	.....	160.3	42.12	29.22	12.89	9.15	......

† Used to indicate approximate time.
* Record is for two days.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading.	Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F °	Per Cent	F °	F °	F °	F °	F °	F °
1	61.2	58.0	56.2	83.7	59.2	49.5	41.2	52.5	48.7	68.1	......	51.6	......	......	46.0	5.6
2	50.8	47.2	44.4	78.9	45.5	44.0	42.6	90.2	43.5	84.5	......	45.2	......	......	41.1	4.1
3	47.0	44.0	41.3	81.2	44.2	44.1	44.0	99.3	42.6	90.3	......	35.3	......	......	31.4	3.9
4	50.1	48.2	46.9	88.8	50.5	49.3	48.4	92.7	47.7	90.7	62.6	41.1	51.8	21.5	36.4	4.7
5	51.0	48.5	46.6	85.3	52.0	46.1	41.0	66.5	43.8	75.9	60.8	46.1	53.5	14.7	43.9	2.2
6	51.2	47.2	44.0	76.8	55.8	51.3	48.0	75.6	46.0	76.2	66.5	36.1	51.3	30.4	32.2	3.9
7	55.5	51.5	48.7	78.1	56.8	55.2	54.2	91.2	51.4	84.7	68.5	42.9	55.7	25.6	32.3	10.6
8	55.3	53.2	51.9	88.2	67.7	53.2	42.4	40.0	47.2	64.1	77.8	42.5	60.1	35.3	38.4	4.1
9	61.5	55.2	51.2	69.0	64.2	53.0	45.0	49.8	48.1	59.4	71.4	56.4	65.4	18.0	49.8	6.6
10	62.4	56.3	52 6	70.3	59.0	54.5	51.6	76.7	52.1	73.5	73.8	46.6	60.2	27.2	41.7	4.9
11	57.5	55.2	53.8	87.5	65.5	59.8	56.8	73.3	55.3	80.4	73.3	51.8	62.6	21.5	49.8	2.0
12	63.2	58.2	55.4	75.7	68.2	59.8	55.2	63.2	55.3	69.4	84.0	46.2	65.1	37.8	43.0	3.2
13	63.2	58.0	55.1	74.7	64.5	57.8	53.9	68.5	54.5	71.6	79.5	50.8	65.1	28.7	46.0	4.8
14	65.5	58.0	53.7	65.5	69.2	61.4	57.5	66.0	55.6	65.8	81.0	50.5	65.8	30.5	45.8	4.7
15	67.4	59.2	54.7	63.6	72.4	63.0	58.4	62.2	56.5	62.9	88.0	52.8	70.4	35.2	47.6	5.2
16	67.0	56.8	50.5	55.5	66.3	46.0	22.4	18.9	36.5	37.2	76.7	47.5	62.1	29.2	41.0	6.5
17	59.2	47.0	35.8	41.6	66.0	49.0	32.2	29.7	34.0	35.6	77.8	46.7	62.2	31 1	39.0	7.7
18	56.5	49.0	43.1	60.8	66.8	56.0	49.1	53.0	46.1	56.9	75.5	39.0	57.3	36.5	35.0	4.0
19	63.5	59.0	56.7	78.4	71.0	61.5	56.6	60.3	56.6	69.4	85.1	48.5	66.8	36.6	44.2	4.3
20	68.0	62.0	59.0	72 9	71.5	63.5	59.6	66.2	59.3	69.5	85.0	54.3	69.6	30.7	49.4	4.9
21	67.0	59.0	54.6	64.2	69.3	60.5	55.8	62.1	55.2	63.2	87.0	56.2	71.6	30.8	49.1	7.1
22	60.0	57.5	56.1	86.9	67.7	57.5	50.3	54.0	53.2	70.4	90.1	46.0	68.1	44.1	43.3	2.7
23	68.5	57.0	49.8	51.5	70.0	59.1	53.1	99.4	51.5	75.5	83.7	45.8	64.7	37.9	42.2	3.6
24	62.8	57.8	55.0	75.5	67.0	61.0	57.9	72.6	56.4	74.0	69.4	56.8	63.1	12.6	50.4	6.4
25	53.3	53.2	53.0	99.4	59.1	58.0	57.4	94.1	55.2	96.8	68.8	52.7	60.8	16.1	52.4	.3
26	60.2	57.8	56.5	87.4	69.0	57.0	49.5	50 0	53.0	68.7	76.5	55.0	65.7	21.5	50.8	4.2
27	63.0	58.0	55.2	75.6	66.0	57.2	52.0	60.5	53.6	68.0	78.1	48.2	63.2	29.9	44.0	4.2
28	67.2	57.2	51.1	56.4	69.5	55.3	45.6	42.4	48.4	49.4	84.8	53.8	69.3	31.0	48.0	5.8
29	68.5	58.2	52.2	56.0	70.5	59.0	52.3	52.8	52.2	54.4	80.5	51.8	66.1	28.7	46.4	5.4
30	63.0	59.0	56.9	80.3	73.2	59.8	52.2	47.7	54.6	64.0	85.4	49.1	67.3	36.3	44.5	4.6
M	60.35	54.88	51.47	73.66	63.92	55.41	49.54	64.38	50.47	69.02	77.58	48.21	63.14	28.87	43.50	4.74

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF JUNE, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Beginning	Total Am't Rain and M'l'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.748	24.765	24.756	Showers in the afternoon.		.18	....	n w	w	170.5	......	.....	......	......	......
24.882	24.975	14.929			.20	....	n w	w	131.3	31.9	25.6	6.3	4.11	......
25.138	25.101	25.119			.27	....	s w	s w	122.0	44.0	25.8	18.2	12.46	Lt F
25.168	25.120	25.144			.16	....	s w	n	148.6	44.6	27.5	17.1	11.81	D
25.090	25.098	25.094			.04	....	n w	s w	151.8	33.2	22.0	11.2	7.25	......
25.151	25.087	25.119			.04	....	0	s w	119.3	......	......	....	. ...	D
25.055	25.062	25.059			.31	....	e	n w	84.8	33.0	24.3	8.7	5.67	......
24.941	24.856	24.903			T	....	0	w	221.2	......	......	......	......	D
24.888	24.858	24.873	1:30p.m	2:20p.m	.01	....	e	e	123.7	......	......	......	.....	......
24.946	25.060	25.003	1:30p.m	3:00p.m	.01	....	e	w	133.9	51.8	34.6	17.2	12.55	......
25.113	25.021	25.067	7:30p.m	Nt.	.08	....	n e	s w	126.9	48.0	30.7	17.3	12.26	......
25.014	24.947	24.981	....	....	......	....	e	n w	104.6	50.7	31.3	19.4	13.92	D
24.933	24.882	24.907	....	....	.....	....	0	e	93.9	......	......	......	.....	.....
24.893	24.816	24.855	....	....	......	....	e	n e	148.5	52.4	37.2	15.2	11.23	......
24.792	24.650	24.721	....	....	......	....	0	n w	155.7	......	......	......	......	D
24.668	24.771	24.719	....	....	......	...	w	w	330.1	47.4	32.2	15.2	10.81	......
24.919	24.809	24.864	....	....	......	...	s w	n w	201.9	45.9	30.7	15.2	10.68	......
25.020	24.937	24.979	....	....	......	....	n e	n e	136.9	.....	......	.....	.....	D
25.067	25.068	25.067	....	....	......	. ..	n e	n w	105.3	49.4	35.0	14.4	10.43	D
25.229	25.114	25.172	....	....	......	....	e	n e	147.7	......	......	......	......	D
25.097	24.980	25.038	1:30p.m	2:35p.m	.11	....	s w	n w	91.3	43.8	34.7	9.1	6.44	Lt D
24.930	24.850	24.890	....	....	......	...	0	n e	135.2	......	......	.....	... ..	D
24.903	24.863	24.883	....	....	......	....	e	e	142.2	47.8	35.4	12.4	8.93	......
25.007	25.066	25.037	8:30p.m	....	......	....	e	s e	169.3	28.6	21.9	6.7	4.26	D
25.124	24.926	25.025	....	7:00p.m	.28	....	s e	s e	123.2	......	......	...	....	......
24.984	24.801	24.892	....	2:00p.m	T	....	n w	s w	155.5	48.2	34.0	14.2	10.20	D
24.792	24.782	24.787	....	....	......	....	e	n w	112.1	......	......	.....	......	D
24.887	24.902	24.895	Nt.	Nt.	T	....	n e	e	161.1	51.7	36.9	14.8	10.90	......
25.115	25.047	25.081	....	....		..	s w	s w	127.1	......	......	......	....	D
25.126	25.024	25.075	....	....		....	s w	s w	126.9	51.3	37.1	14.2	10.44	D
24.987	24.942	24.964	....	....	1.69	....	......	......	143.4	44.65	30.94	13.71	9.69	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	63.0	58.2	55.5	76.5	72.0	59.5	52.3	50.1	53.9	63.3	88.8	50.4	69.6	38.4	44.5	5.9
2	69.7	60.0	54.7	58.9	57.5	54.0	51.8	81.2	53.2	70.0	86.5	51.0	68.7	35.5	47.0	4.0
3	53.3	49.0	45.7	75.8	59.0	47.0	36.0	42.3	40.9	59.1	72.6	54.0	63.3	18.6	50.9	3.1
4	59.5	50.5	43.6	55.7	64.0	51.0	40.7	42.5	42.1	49.1	76.3	41.4	58.9	34.9	35.5	5.9
5	61.0	51.8	45.1	55.9	70.1	65.0	62.7	77.4	53.9	66.6	89.9	42.9	66.4	47.0	36.3	6.6
6	69.0	58.8	52.9	56.6	72.0	63.0	58.6	62.6	55.8	59.6	90.6	51.4	71.0	39.2	44.2	7.2
7	66.2	54.0	45.5	47.4	75.0	64.0	58.7	57.0	52.1	52.2	94.8	51.0	72.9	43.8	43.8	7.2
8	73.0	63.8	59.4	62.7	61.5	61.0	60.7	97.4	60.0	80.1	89.3	55.4	72.3	33.9	49.0	6.4
9	59.3	59.2	59.2	99.4	58.5	56.0	54.5	86.7	56.9	93.0	66.9	57.9	62.4	9.0	56.4	1.5
10	56.0	54.0	52.9	88.9	63.5	58.0	54.9	73.5	53.9	81.2	74.5	47.4	61.0	27.1	43.2	4.2
11	63.5	57.5	54.0	71.2	72.0	60.0	53.3	52.0	53.6	61.6	82.0	48.0	65.0	34.0	43.3	4.7
12	64.6	59.6	57.0	76.1	72.0	62.8	58.3	62.3	57.7	69.2	84.1	51.7	67.9	32.4	46.5	5.2
13	66.2	60.6	57.7	74.0	72.4	61.8	56.4	57.1	57.0	65.6	93.0	50.0	71.5	43.0	44.8	5.2
14	63.0	57.2	53.9	71.9	61.0	56.5	53.8	77.3	53.9	74.6	77.0	64.3	70.6	12.7	45.2	19.1
15	61.5	57.5	55.2	79.9	70.0	59.2	53.1	55.1	54.1	67.5	83.8	45.4	64.6	38.4	41.1	4.3
16	69.0	59.8	54.7	60.4	69.0	57.0	49.5	50.0	52.1	55.2	82.3	50.5	66.4	31.8	46.1	4.4
17	63.0	56.2	52.1	67.4	66.0	59.3	55.7	69.2	53.9	68.3	85.2	49.8	67.5	35.4	44.9	4.9
18	59.6	55.2	52.5	77.4	58.3	56.0	54.6	87.7	53.6	82.5	74.6	52.5	63.6	22.1	48.2	4.3
19	52.3	49.7	47.8	85.0	53.7	51.2	48.8	85.8	48.3	85.4	62.1	48.1	55.1	14.0	46.6	1.5
20	54.5	51.5	49.4	83.2	64.4	57.4	53.3	67.2	51.3	75.2	76.9	38.9	57.9	38.0	36.0	2.9
21	62.0	56.3	52.8	72.0	66.0	61.0	58.5	76.6	57.7	74.3	85.0	44.8	64.9	40.2	40.2	4.6
22	61.2	56.2	53.2	75.0	68.0	59.3	54.5	61.9	53.8	68.5	84.1	52.6	68.3	31.5	45.9	6.7
23	64.0	59.2	56.6	76.9	60.0	58.3	57.3	91.0	57.0	83.9	83.0	51.3	67.2	31.7	45.7	5.6
24	58.2	56.6	55.7	91.3	62.0	57.8	55.5	79.1	55.6	85.2	76.0	54.4	65.2	21.6	51.0	3.4
25	63.0	59.3	57.3	81.7	72.2	57.2	47.6	41.4	52.4	61.6	87.0	48.1	67.5	38.9	44.0	4.1
26	64.3	58.1	54.6	70.6	72.1	55.2	43.2	35.5	48.9	53.0	87.1	48.4	67.8	38.7	41.8	6.6
27	62.3	56.7	53.4	72.6	71.8	55.8	44.8	38.1	49.1	55.4	88.6	48.4	68.5	40.2	42.8	5.6
28	64.5	59.0	56.0	73.8	69.5	61.0	56.5	63.3	56.3	68.5	94.0	46.9	70.4	47.1	40.1	6.8
29	65.8	59.5	56.0	70.8	71.0	60.3	54.5	56.0	55.2	63.4	90.9	49.3	70.1	41.6	41.9	7.4
30	66.5	60.0	56.5	70.2	76.8	60.0	50.1	39.2	53.3	54.7	85.0	57.9	71.5	27.1	49.0	8.9
31	71.0	62.3	58.0	63.3	71.5	61.2	55.8	57.7	56.9	60.5	89.0	57.8	73.4	31.2	50.9	6.9
M	62.90	57.01	53.51	72.34	66.86	58.28	53.10	63.68	53.30	68.01	83.25	50.38	66.82	32.87	44.74	5.65

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF JULY, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION.				Direction of Wind		Total Movement for 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'l'td Snow	Ag'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal.	
25.019	24.878	24.948	......	......	......	....	0	s w	118.9	43.5	34.6	8.9	6.29	D
24.726	24.677	24.702	7 p. m.	7.20p.m	.05	....	n e	n w	288.6	......	......	......	......	D
24.724	24.836	24.780	......	......	......	....	s w	n e	192.3	......	......	......	......	......
25.000	24.981	24.990	......	......	......	....	s w	n e	140.6	......	......	......	......	D
25.024	24.832	24.928	......	......	......	....	e	n w	158.5	48.7	37.0	11.7	8.51	......
24.942	24.742	24.842	......	......	......	....	n e	n w	149.1	......	......	......	......	D
24.964	24.875	24.920	......	......	......	....	s w	n w	140.8	56.8	42.7	14.1	10.82	D
24.991	25.135	25.063	1.30p.m	......	.28	....	s w	n	133.4	41.3	34.0	7.3	5.10	......
25.167	25.184	25.175	......	12.4p.m	.90	....	0	n e	85.9	......	......	......	......	......
25.285	25.249	25.267	Nt.	Nt.	.13	....	e	s w	113.3	45.0	30.2	14.8	10.34	......
25.290	25.233	25.262	......	......	......	....	0	s w	128.1	......	......	......	......	D
25.266	25.114	25.190	......	......	......	....	0	n e	113.2	50.0	35.4	14.6	10.61	D
25.063	24.951	25.007	......	......	......	....	s	s w	143.5	......	......	......	......	D
25.051	25.111	25.081	7 a. m.	10 a. m	.19	....	e	e	143.5	......	......	......	......	......
25.112	25.060	25.086	......	......	......	....	s w	s e	112.1	51.0	36.5	14.5	10.62	D
25.086	24.988	25.037	......	......	......	....	0	s w	126.2	40.7	31.4	9.3	12.96	D
24.988	24.931	24.959	Nt.	Nt.	......	....	0	s w	139.9	52.1	36.8	15.3	11.27	D
25.093	25.059	25.076	4 p. m.	Nt.	.21	....	n w	n w	182.4	......	......	......	......	......
25.229	25.227	25.228	2 p. m.	4 00p.m	.68	....	s w	s e	130.5	44.7	27.4	17.3	11.95	......
25.188	25.074	25.131	......	......	......	....	s w	s w	149.6	......	......	......	......	Hv D
25.090	25.010	25.050	......	......	......	....	0	n w	114.1	51.7	37.7	14.0	10.34	D
25.024	24.936	24.980	......	......	......	....	s e	n e	96.7	47.0	34.8	12.2	8.74	D
25.029	25.130	25.080	6.30p.m	Nt.	.04	....	n e	w	160.8	57.7	40.6	17.1	13.12	D
25.065	25.037	25.051	2.30p.m	3 p. m.	.17	....	e	s w	121.0	50.1	34.2	15.9	11.51	......
25.154	25.204	25.179	......	......	......	....	0	e	115.7	......	......	......	......	D
25.249	25.262	25.255	2.30p.m	2.45p.m	T	....	e	w	136.2	44.9	35.9	9.0	6.42	D
25.233	25.140	25.187	......	......	......	....	n e	w	113.3	......	......	......	......	D
25.153	25.072	25.112	......	......	......	....	n e	n w	100.1	58.6	43.6	15.0	11.63	D
25.090	25.060	25.075	......	......	......	....	s w	e	151.6	......	......	......	......	D
25.171	25.090	25.131	......	......	......	....	e	s w	160.0	......	......	......	......	D
25.145	25.123	25.134	Nt.	Nt.	T	....	s w	s w	114.3	54.0	39.4	14.6	10.94	......
25.084	25.039	25.061	......	......	2.65	....	......	......	137.9	49.28	36.01	13.27	10.07	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading.	Radiation
	F °	F °	F °	Per Cent.	F °	F °	F °	Per Cent.	F °	Per Cent.	F °	F °	F °	F °	F °	F °
1	66.0	61.3	59.0	78.0	70.0	58.1	51.0	51.0	55.0	64.5	86.1	53.5	69.8	32.5	48.2	5.4
2	65.5	59.8	56.8	73.3	65.0	61.3	59.4	82.2	58.1	77.7	82.1	55.9	69.0	26.2	48.3	7.6
3	61.0	58.3	56.8	86.2	60.0	58.8	58.2	93.7	57.5	90.0	74.2	56.8	65.5	17.4	52.5	4.3
4	58.8	58.2	57.9	96.7	61.2	61.2	61.2	100.0	59.5	98.3	68.7	57.4	63.1	11.3	52.3	5.1
5	61.0	59.5	58.7	92.2	69.0	65.3	63.6	85.2	61.2	87.7	82.4	58.8	70.6	23.6	58.1	0.7
6	65.1	61.1	59.1	80.8	62.0	61.2	60.8	95.8	59.9	88.3	86.6	54.5	70.5	32.1	49.7	4.8
7	58.5	57.0	56.1	91.9	66.2	61.1	58.6	76.2	57.4	84.1	85.5	52.8	69.2	32.7	46 3	6.5
8	64.6	61.5	60.0	85.0	67.0	61.1	58.1	75.0	59.0	79.0	80.3	54.2	67.2	26.1	48.0	6.2
9	59.5	59.5	59.5	100.0	66.5	61.5	59.0	76.8	59.3	88.4	81.2	55.7	68.5	25.5	49.5	6.2
10	62.3	59.3	57.7	85.0	67.3	63.2	61.3	81.0	59.5	83.0	77.0	53.7	65.3	23.3	49.4	4.3
11	60.1	60.1	60.1	100 0	67.0	59.2	54.9	65.0	57.5	82.5	85.8	55.4	70.6	30.4	49.3	6.1
12	62.8	58.0	55 3	76.4	68.1	58.1	52.2	56.9	53.7	66.6	89.2	49.6	69.4	39.6	44.0	5.6
13	69.7	58.1	51.2	51.9	68.1	59.0	53.9	60.4	52.6	56.2	87.0	54.5	70.8	32.5	49.5	5.0
14	60.9	56.3	53.6	76.9	68.7	60.7	56.5	65.0	55.0	10.9	78.9	54.6	66.7	24.3	49.7	4.9
15	59.8	53.1	48.6	66.4	61.0	56.2	53.3	75.9	51.0	71.2	75.5	56.9	66.2	18.6	52.1	4.8
16	60.8	56.9	54.6	80.2	67.1	59.0	54.5	63 8	54.6	72.0	84.7	48.8	66.8	35.9	44.7	4.1
17	61.1	56.1	53.1	74.9	62.1	56.2	52.6	71.4	52.9	73.1	80.8	47.8	64.3	33.0	45.4	2.4
18	56.8	53.1	50.7	86.0	60.0	56.8	55.0	83.5	52.8	81.8	77.1	47.9	62.5	29.2	43.1	4.8
19	58.0	53.2	50.0	74.8	59.9	54.4	50.9	72.2	50.5	73.5	79.1	43.2	61.1	35.9	40.1	3.1
20	58.9	53.9	50.7	74.2	60.9	53.7	49.0	64.7	49.8	69.4	83.0	42.7	62.9	40.3	39.9	2.8
21	56.1	53 1	51.1	89.6	62.1	54.0	48.6	61.3	49.9	72.5	77.0	45.0	61.0	32.0	40.9	4.1
22	58.9	54.9	52.4	79.2	63.3	55.9	51.3	64.9	51.8	72.0	82.6	46·0	64.3	36.6	41.7	4.3
23	64.8	53.9	46.3	51.4	63.8	55.8	50.9	62.7	48.6	57.1	80.9	51.1	66.0	29.8	44.2	6.9
24	57·8	53.2	50.2	75.7	66.3	55.0	47.5	50.9	48.9	63.3	91.1	45.1	68.1	46.0	41.0	4.1
25	58.9	54.1	51.0	75.1	73.3	58.2	36.8	26.7	43.9	50.9	93.5	45.0	69.2	48.5	40 2	4.8
26	63.0	54 9	49.7	61.8	61.8	54.2	49.2	63.4	49.4	62.6	76.8	59.7	68.3	17.1	51.7	8.0
27	60.0	55 8	52.4	76.0	66.7	57.4	51.8	58.8	52.1	67.4	83.1	48.3	65.7	34.8	44.0	4.3
28	63.2	57.9	54.9	74.3	70.6	56.1	46.4	42.2	50.7	58.2	83.6	50.8	67.2	32.8	45.9	4.9
29	53.8	53.5	53.2	98.3	63.9	55.7	50.6	61.9	51.9	80.1	78.7	54.8	66.7	23.9	50.8	4.0
30	59.1	55.1	52.6	79.2	70.1	58.0	50.7	50.3	51 6	64.8	87.7	46.8	67.3	40.9	43.7	3.1
31	60.1	53.7	49.5	67.9	65.2	51.7	41.2	41.7	45.4	54.8	91.3	46.0	68.6	45.3	43.0	3.0
M	60.87	56.58	53.96	78.95	65.30	57.84	53.19	66.98	53.58	72.96	32.31	51.40	66.85	30.91	46.68	4.72

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF AUGUST, 1897.

Barometer Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and Mlt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C	C	C	Cal.	
25.111	25.030	25.070					0	s w	167.6	.....	.....	.....	.....	D
25.083	25.070	25.077	Nt	Nt		...	e	e	131.6	51.2	37.1	14.1	10.37	D
25.162	25.173	25.167	Showers in	Afternoon.	.24		s w	n e	88.6	.....	.....	.....	.....	.....
25.276	26.295	25.286			.06		n	s w	102.9	23.5	20.2	3.3	1.98	.....
25.286	25.222	25.254			.07	..	e	n	99.1	48.2	34.2	14.0	10.56	.....
25.241	25.180	25.210			.06		s e	s w	109.6	52.4	37.6	14.8	10.95	D
25.149	25.121	25.135			.24	.	n e	0	101.7	.....	.....	.....	.....	D
25.121	25.058*	25.09[illegible]			.	..	n e	n e	111.5	.....	.....	.....	.....	D
25.128	25.088	25.108	1:50p.m.	2:10p.m	.13		s w	n w	106.1	49.4	34.9	14.5	10.50	D
25.201	25.155	25.178	Nt.	Nt.	.11		0	n e	74.1	.....	.....	.....	.....	....
25.162	25.071	25.116			....		0	n e	96.4	51.7	37.5	14.2	10.55	D
25.053	24.964	25.009	4:40p.m	4:55p.m	.03	..	0	n w	128.4	53.0	38.4	14.6	10.86	D
25.011	25.045	25.028	5:10p.m	..	T		n w	n w	134.1	.....	.....	.....	.....	D
25.136	25.115	25.125			....		n e	s w	108.8	48.6	33.8	14.8	10.63	D
25.234	25.163	25.199			. . .	.	n	n w	82.4	.....	.....	.....	.....	D
25.139	25.060	25.099	....	....	.	..	n	n	89.4	50.7	36.0	14.7	10.74	Hv D
25.132	25.207	25.170	8hrs pm	....	.63		n w	s w	152.6	.....	.....	.....	.....	Hv D
25.283	25.249	25.266	8:50p.m	4 p. m.	.04		n w	e	102.0	47.1	32.0	15.1	10.71	Hv D
25.301	25.212	25.256		.	.		n	n e	97.0	49.7	34.5	15.2	11.00	Hv D
25.218	25.140	25.179			....		n w	0	106.7	.....	.....	.....	.....	Hv D
25.231	25.153	25.192		...	......	..	0	e	120.8	49.0	33.6	15.4	11.07	D
25.194	25.099	25.147		.	. . .		n w	w	132.7	.....	.....	.....	.....	D
25.200	25.170	25.185		.	.	.....	n w	n w	118.4	51.0	35.8	15.2	11.11	....
25.143	25.002	25.072	.	. .	..		0	n w	98.0	.....	.....	.....	.....	D
25.005	24.890	24.948		.	..		0	w	165.5	58.1	42.9	14.2	11.65	D
25.150	25.080	25.115	4 p. m.		T	..	s e	n	128.9	51.0	34.2	16.8	12.20	......
25.047	24.981	25.014	. .		...		s e	w	128.9	33.7	28.5	5.2	3.46	D
25.015	25.022	25.018	3 p. m.	.	.02	..	0	n w	148.7	34.7	28.0	6.7	4.46	D
25.258	25.141	25.200	6:50a.m	7:25a m	.11		n w	s	168.2	.....	.....	.....	.....	R
25.092	24.936	25.014		.	....		0	s w	105.7	53.0	38.7	14.3	10.65	D
24.931	24.866	24.898	..		....		s w	n	125.0	.....	.....	.....	.....	D
25.151	25.095	25.123		.	1.74	.	......	....	117.2	47.56	34.33	13.23	9.64	.....

* The reading in original seems by the aneroid to be .5 inches in error and this is therefore corrected by that amount.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.															
	7 A. M.				7 P. M.				Dail Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent	F°	F°	F°	Per Cent	F°	Per Cent	F°	F°	F°	F°	F°	F°
1	56.7	51.1	47.4	71.2	67.3	56.9	50.5	54.9	48.9	63.0	87.0	53.9	70.4	33 1	49.0	4.9
2	59.3	54.9	52.1	77.3	65.5	56.3	50.6	58.6	51.4	68.0	87.2	49.0	68.1	38.2	44.5	4.5
3	61.0	56.6	54.0	77.8	64.0	54.2	47.7	55.3	50.8	66.5	88.0	53.3	70.7	34.7	49.0	4.3
4	65.0	52.8	43.9	46.5	70 8	55.0	43.9	38.0	43.9	42.3	89.0	46.2	67.6	42.8	42.5	3.7
5	61.0	53.1	47.7	61.6	76.2	54.2	36.4	23.9	42.1	42.7	87.2	50.0	68.6	37.2	44.2	5.8
6	64.4	58.2	54.7	70.7	64.1	56.0	51.0	62.4	52.8	66.6	89.0	49.0	69.0	40.0	46.0	3.0
7	64.6	54.6	48.0	54.8	71.8	60.5	54.3	54.3	51.2	54.5	89.8	51 3	70.5	38.5	47.0	4.3
8	62.0	56.0	52.3	70.6	69.2	57.8	50.9	52.3	51.6	61.5	86.2	52.0	69.1	34.2	47.2	4.8
9	54.9	49.5	45.4	70.5	55 2	51.0	48.0	77.0	46.7	73.7	62 0	54.0	58.0	8.0	53.0	1.0
10	50.6	50.0	49.6	96.4	58.0	54.1	51.6	79.4	50.6	87.9	68.7	49 0	58 9	19.7	48.5	0.5
11	59.8	57.8	56.8	89.5	66.0	59.8	56.5	71.3	56.6	80.4	78.0	48.2	63.1	29.8	45.0	3.2
12	60.3	57.0	55.2	83.0	61.1	59.8	59.1	93.3	57.2	88.2	82.5	49.0	65.7	33.5	46.0	3.0
13	60.3	57.8	56.4	87.0	61.9	60.1	59.2	90.7	57.8	88.8	82.8	51 3	67.1	31.5	48.0	3.3
14	59.0	57.2	56.2	90.4	60.0	55.8	53.3	78.5	54.7	84.5	77.8	57.5	67.6	20.3	54 5	3.0
15	55.9	54.2	53.1	90.5	61.7	52.0	44.9	54.2	49.0	72.3	77.8	50 6	64.2	27.2	48.0	2.6
16	42.2	39.0	35.5	78.0	43.4	41.0	38.6	83 8	37.1	81.9	45.0	40.2	42.6	4.8	38.5	1.7
17	41.3	40.0	38.7	90.8	56.8	48 0	40.7	54.8	39.7	72.8	74.2	33.8	54.0	40.4	30.8	3.5
18	53.8	49.0	45.4	73.2	55.5	47.4	40.6	57.3	43.0	65 3	77.5	38.0	57.8	39.5	33.8	4.2
19	49.3	46.2	43.6	81.3	55 0	49.0	44.4	67.4	44.0	74.3	77.0	33.0	57.5	39.0	34.0	4.0
20	51.2	47.3	44.2	77.3	60.1	53.8	49.7	68.4	46.9	72.9	82.0	44.0	63.0	38.0	39 0	5.0
21	56.8	52.1	48.9	74.9	60.5	49.0	39.4	45.7	44.2	60.3	82.5	46.0	64 2	36.5	39 2	6.8
22	56.2	51.3	47 8	73.6	60 4	52.8	47.6	62.6	47.7	68.1	81 8	47.0	64.4	34.8	41.5	5 5
23	53.5	48.0	43.6	69.4	68.0	52.0	39.2	34.9	41 4	52 1	82.0	40.2	61.1	41.8	......	....
24	60.2	53.0	48.1	64.3	55.0	50.	47.4	75.8	47.7	70.1	75.5	56.0	65 8	19.5	49.0	7.0
25	53.4	50.0	47.5	80.7	57.8	52.2	48.3	70.7	47.9	75.7	79.0	45.0	62 0	34.0	39.0	6.0
26	58.0	52.5	48.7	71.3	61.3	51.8	44.8	54.8	46.8	63.0	82.8	48.6	65.7	34.2	43.6	5.0
27	54.2	49.4	45.8	73.4	64.0	54.2	47.7	55.3	46.7	64.4	82.0	45.0	63.5	37.0	40.0	5.0
28	48.8	45.0	41.8	77.1	66.8	55.8	48.7	52.4	45.3	64.7	84.5	41.5	63.0	43.0	36.5	5.0
29	53.8	49.6	46.5	76.5	60.3	52.7	47.5	60.3	47.0	64.4	80.2	48.0	64.1	32 2	42.0	6.0
30	54.5	51.9	50.1	85.4	56.2	51.8	48.7	76.3	49.4	80.9	82.1	46.0	64.0	36.1	41.4	4.6
M	56.07	51.50	48.30	76.17	61.80	53.52	47.71	62.15	48.00	69.16	80.04	47.39	63.71	32.65	43.11	4.18

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF SEPTEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.993	24.945	24.969	......	......	......	....	0	n	95.0	57.0	40.4	16.6	12.63	......
24.966	24.829	24.897	......	......	......	....	......	n w	100.3	49.5	36.6	12.9	9.40	......
24.976	24.973	24.975	......	......	......	....	0	0	115.5	......	......	......	......	D
25.129	25.055	25.092	......	......	......	....	0	w	154.9	......	......	......	......	D
25.143	25.048	25.095	......	......	......	....	n w	w	129.6	......	......	......	......	Lt D
25.044	24.981	25.013	......	......	......	....	e [o]	0	106.6	......	......	......	......	D
25.044	24.899	24.971	......	......	......	....	......	0	141.6	......	......	......	......	D
24.873	24.827	24.850	......	......	......	....	s e	s e	171.0	......	......	......	......	Lt D
25.135	25.128	25.132	......	......	......	....	......	s w	123.8	......	......	......	......	......
25.173	25.125	25.149	7:30 a.m	8:30 a.m	.01	....	0	0	101.8	......	......	......	......	......
25.201	25.082	25.141	7:25p.m	......	......	....	s e	w	106.0	......	......	......	......	......
25.101	25.051	25.076	4:45p.m	6:00p.m	.08	....	n w	0	99.2	......	......	......	......	Lt D
25.038	24.972	25.005	6:15p.m	9:00p.m	.39	....	0	n e	124.2	56.3	36.8	19.5	14.59	......
25.051	25.001	25.026	7:30 a.m	......	.22	....	n e	w	109.5	......	......	......	......	......
25.090	25.159	25.125	5:30p.m	......	.03	....	0	e	189.0	52.5	34.5	18.0	13.17	D
25.489	25.403	25.446	......	......	.02	....	s w	e	133.8	......	......	......	......	......
25.417	25.265	25.341	......	......	......	....	0	w	250.7	41.5	26.1	15.4	10.45	Lt F
25.291	25.241	25.266	......	......	......	....	n w	w	*	......	......	......	......	D
25.321	25.235	25.278	......	......	......	....	0	......	88.8	......	......	......	......	D
25.284	25.210	25.247	......	......	......	....	0	0	99.5	......	......	......	......	D
25.258	25.1[illegible]9	25.228	......	......	......	....	0	0	194.8	......	......	......	......	......
25.[illegible]45	25.176	25.211	......	......	......	....	0	0	*	......	......	......	......	D
25.189	25.136	25.162	......	......	......	....	n w	n	117.2	......	......	......	......	D
25.174	25.17[illegible]	25.177	......	......	......	....	n	s w	123.9	......	......	......	......	...
25.213	25.156	25.184	......	......	......	....	w	w	93.0	......	......	......	......	D
25.170	25.080	25.125	......	......	......	....	......	n	108.6	......	......	......	......	D
25.147	25.113	25.130	......	......	......	....	0	0	107.0	51.5	36.0	15.5	11.36	D
25.160	25.044	25.102	7:00p.m	......	......	....	0	w	93.7	52.4	36.7	15.7	11.57	D
25.147	25.146	25.147	......	......	T	....	......	n w	98.8	46.1	31.7	14.4	10.[illegible]6	D
25.205	25.120	25.162	3:10p.m	......	T	....	0	n w	105.6	51.5	36.2	15.3	11.22	D
25.156	25.093	25.124	......	......	0.75	....	......	......	116.1	50.92	35.00	15.92	11.62	......

* Two days record.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY.														Terrestrial Radiation	
	7 A. M.				7 P. M.				Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range		
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F °	Per Cent	F °	F °	F °	F °	F °	F °
1	50.9	48.4	46.5	85.3	64.1	50.9	40.4	41.9	43.4	63.6	76.3	42.0	59.1	34.3	37.8	4.2
2	51.0	46.2	42.2	72.1	57.9	49.1	42.1	55.5	42.2	63.8	78.7	41.2	60.0	37.5	37.0	4.2
3	50.3	45.9	42.2	74.0	57.2	50.4	45.4	64.6	43.8	69.3	70.9	43.0	56.9	27.9	39.0	4 0
4	43.1	41.1	39.2	86.4	55.0	47.7	41.7	60.8	40.4	73.6	77.0	38.6	57.8	38.4	34.3	4.3
5	46.2	41.2	36.1	68.4	53.2	44.7	36.7	53.7	36.4	61.0	74.0	37.9	56 0	36.1	32.4	5.5
6	45.0	40.8	36.6	72.8	57.1	45.9	35.3	44.2	36.0	58.5	81.7	35.0	58.3	46 7	29 9	5.1
7	45.2	41.3	37.4	74.9	57.7	53.8	51.3	79.3	44.3	77.1	80.2	47.0	58.6	43.2	32.0	5.0
8	43.0	41.5	40.0	89.7	46.6	42.3	38.2	73.0	39.1	81.4	49.7	41.9	45.8	7.8	40.8	0.7
9	37.3	33.3	28.0	69.1	46.2	42.9	39.8	79.1	33.9	74.1	59.2	33.7	46.5	25.5	29.9	3.8
10	48.3	41.2	33.6	57.3	44.1	37.9	30.6	59.4	32.1	58.3	62.8	42.9	52.8	19.9	37.7	5.2
11	39.7	36.7	33.2	78.1	44.3	38.3	31.4	60.8	32.3	69.5	75.9	32.4	54.2	43.5	28.7	4.1
12	33.7	31.8	29.2	83.5	53.4	45.0	37.2	54.3	33.2	68.9	71.0	27.5	49.2	43.5	24.0	3.5
13	41.9	37.8	33.2	71.7	58.0	45.0	31.7	37.1	32.5	54.4	80.0	39.3	59.7	40.7	34.0	5.2
14	51.6	44.1	37.0	57.5	55.7	45.0	34.5	45.2	35.7	51.3	73.0	38.0	55.5	35.0	34.0	4.0
15	36.8	35.0	32.8	85.6	38.9	34.9	29.9	70.3	31.4	78.0	63.3	33.0	48.1	30.3	28 0	5.0
16	30.7	30.7	30.7	100.0	30.1	30.1	30.1	100.0	30.4	100.0	35.6	29.3	32.5	6 3	29.0	0.3
17	27.2	26.9	26.4	96.9	30.0	29.2	28.0	92.3	27.2	94.6	38.7	26.0	32.3	12.7	26.0	0.0
18	31.2	30.8	30.2	96.2	43.4	37.0	29.2	57.5	29.7	76.8	67.0	28.4	47.7	38.6	23.6	4.8
19	30.4	29.9	29.2	95.2	41.9	37.0	31.1	66.2	30.1	80.7	69.0	24.0	46.5	45.0	19.7	4.3
20	36.6	3 .0	25.5	63.8	48.0	38.1	25.5	41.3	25.5	52.6	71.7	28.7	50.2	43.0	24.3	4.4
21	32.7	31.7	30.4	91.1	45.1	38.2	30.0	55.7	30.2	73.4	72.4	26.0	49.2	46.4	21.1	4.9
22	32.8	31.1	28.7	84.9	48.2	39.0	27.9	45.3	28.3	65.1	69.0	30.5	49·8	38.5	27.0	3.5
23	32.1	30.1	27.2	81.8	40.1	35.2	29.0	64.8	28.1	73.3	*† 69.8	30.0	49.9	39.8	25.0	5.0
24	34.9	31.9	27.8	75.3	47.1	38.9	29.2	49.8	28.5	62.5	71.8	29.0	51.9	45.8	25.0	4.0
25	45.6	37.9	28.5	51.3	39.9	35.2	29.2	66.0	28.9	58.7	55.7	39.1	47.4	16.6	32.8	6.3
26	31.9	31 9	31.9	100 0	26.0	26.0	26.0	100.0	28.9	100.0	33.5	*26.0	29.7	7.5	‡30.6	0.5
27	26.7	23.9	18.6	71.0	34.6	28.2	16.9	47.5	17.8	59.2	42.7	24.3	33.5	18.4	21.1	3.2
28	33.9	29.7	23.3	64.5	31.7	29.9	27.3	83.5	25.3	74.0	51.0	25.7	38.4	25.3	19.2	6.5
29	30.8	29.2	26.9	85 0	39.2	36.9	34.3	82.9	30.6	84 0	68.8	22.3	45.5	46.5	17.9	4.4
30	37.8	31.8	22.9	54.6	37.0	35.4	33.5	87.3	28.2	70.9	*54.5	21.5	38.0	33.0	16.5	5.0
31	34.9	31.7	27.3	73.6	34.0	31.1	27.0	75.4	27.1	74.5	62.0	25.7	43.9	36.3	19.7	6.0
M	38.52	35.40	31.79	77 79	45.35	39.33	32.92	61.35	32.31	71.07	64.84	32.25	48.53	32.58	28 32	4.1

* Minimum temperatnre of day occurred between 7 a. m. and 7 p. m.
† Richard Self Register.
‡ Radiation from minimum reading at 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1.—Continued.

FORT COLLINS, COLO., FOR MONTH OF OCTOBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins			Miles	C°	C°	C°	Cal.	
25.054	24.886	24.970	....	....	......	....	s e	s w	140.6	43.8	31.2	12.6	8.80	D
25.078	25.105	25.091	....	....	......	....	0	n w	153.2	46.4	32.8	13.6	9.65	D
25.150	25.172	25.161	....	....	......	....	s e	n	111.0	......	......	......	......	D
25.222	25.219	25.221	Nt.	Nt.	T	....	n w	s	113.8	49.6	33.4	16.2	11.67	D
25.409	25.327	25.368	....	....	......	....	w	0	113.0	47.6	31.3	16.3	11.56	D
25.302	25.174	25.238	....	....	......	...	s e	w	108.0	51.4	35.2	16.2	11.83	F
25.111	25.077	25.094	6:04p.m	....	.02	....	w	n	145.8	......	......	......	.....	D
25.273	25.182	25.227	a.m	Nt.	.18	....	n w	s w	141.0	17.5	11.6	5.9	3.46	R
25.018	24.838	24.928	....	....	.....	....	n w	s w	155.0	27.0	16.7	10.3	6.38	F
25.962	24.853	24.908	......	......	......	..	n	w	124.9	......	......	....	......	......
24.762	24.846	24.804	......	...	......	..	w	n e	181.5	41.2	29.9	11.3	7.77	F
24.855	24.719	24.787	.. ..	....	......	...	n e	w	126.6	.....	...	....	.....	F
24.744	24.808	24.776	......	...	....	...	n e	0	233.6	....	.....	....	....	......
24.837	24.862	24.849	......	...	....	..	w	w	126.4	......	......	...	....	......
25.027	25.199	25.113	5:30p.m	. ..	T	..	0	n e	183.2	......	......	.	...	F
25.393	25.317	25.355	....	....	.28	2	n	n e	108.6	......	......	.....	....	Lt Sn
25.186	25.027	25.106	Nt.	Nt.	.01	1	e	n w	66.1	.....	....	.....	.....	......
25.041	25.077	25.059	....	. .	......	..	w	n e	121.5	42.9	25.5	17.4	11.8	Hv. F
25.091	24.994	25.044		. .	......	.	0	0	114.1	.....	......	.. ..	......	F
24.978	25.040	25.009	. .	......	......	....	n w	s	161.6	53.4	32.5	20.9	15.23	F
25.077	24.944	25.011	...	....	....	..	n w	s w	103.9	46.5	29.3	17.2	12.06	F
24.892	24.955	24.923	..	.... ..	......	..	w	n w	96.8	31.4	23.5	7.9	5.31	......
25.033	24.896	24.965	.....	.....	.....	..	......	w	102.3	......	....	.	...	F
24.809	24.719	24.764	. . .	....	......		n w	w	121.9	......	......	....	.....	F
24.709	24.821	24.765	12:35pm	. ...	T	...	n e	n	401.8	16.9	13.0	3.9	2.29	F
25.045	25.189	25.117	6:50a.m	......	.09	...	n	n e	395.6	....	......	...	....	Sn
25.172	25.206	25.189	6:36p.m	Nt.	.17	2	n w	n	153.7	....	...	.....	......	Sn
25.284	25.176	25.230	. ..	....	......	..	s	w	140.8	38.4	20.2	18.2	11.94	.
25.104	25.001	25.053	. ..	.. .	......	..	w	w	105.7	46.3	29.6	16.7	11.70	F
24.952	25.069	25.010		... ..	......		0	n w	229.6	......	......	.....	......	F
25.192	25.221	25.206	... .		...	..	n	s w	188.9	....	......	......	......	F
25.057	25.023	25.042	......	......	0.75	5	....	...	152.4	40.02	26.38	13.64	9.42	......

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE.

	TEMP., DEW POINT AND RELATIVE HUMIDITY.								Daily Mean Dew Point.	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point.	Relative Humidity							Instrument Reading	Radiation
	F °	F °	F °	Per Cent	F °	F °	F °	Per Cent	F °	Per Cent	F °	F °	F °	F °	F °	F °
1	26.1	24.8	22.5	86.1	37.0	32.8	27.1	67.3	24.8	76.7	70.0	21.8	45.9	48.2	18.0	3.8
2	28.4	26.8	24.2	84.0	38.0	34.2	29.3	71.2	26.7	77.6	70.2	23.8	47.0	46.4	20.0	3.8
3	32.0	29.9	26.8	81.0	41.8	35.7	27.9	58.0	27.4	69.5	68.9	28.7	46.3	35.2	24.0	4.7
4	31.8	29.0	24.8	74.8	24.9	24.0	22.4	90.2	23.6	82.5	46.7	30.3	38.5	16.4	28.1	2.2
5	18.8	18.2	16.9	92.2	29.1	26.6	22.4	75.6	19.6	83.9	49.2	13.0	31.1	36.2	8.0	5.0
6	32.6	29.6	25.0	73.7	36.0	34.0	31.5	83.7	28.3	78.7	50.0	20.0	35.0	30.0	15.8	4.2
7	29.1	29.1	29.1	100.	36.8	29.8	18.0	45.9	23.5	72.9	43.4	28.0	35.7	15.4	28.2	-0.2
8	28.9	22.1	5.1	35.8	25.9	21.1	9.8	50.3	7.5	43.1	38.7	†27.0	32.8	11.7	*21.0	6.0
9	32.9	25.7	10.5	38.8	46.5	35.0	17.2	30.6	13.8	34.7	°57.2	18.0	37.6	39.2	11.0	7.0
10	54.0	40.8	24.4	31.9	34.4	31.7	28.0	77.3	26 2	54.6	64.8	38.0	51.4	26.8	34.3	3.7
11	24.8	24.2	23.2	93.4	53.1	42.9	32.1	45.2	27.7	69.3	72.3	21.7	47.0	50.6	17.8	3.9
12	38.8	35.3	31.0	73.9	61.3	46.8	32.8	34.2	31.9	54.0	75.0	32.7	53.9	42.3	27.2	5.5
13	38.8	35.0	30.3	71.8	45.5	36.5	24.5	43.4	27.4	57.6	70.2	36.8	53.5	33.4	31.8	5.0
14	27.4	25.5	22.2	80.5	41.8	36.1	29.0	60.7	25.6	70.6	62.4	26.0	44.2	36.4	20.4	5.6
15	25.0	24.6	23.9	95.6	9.6	9.4	8.8	96.6	16.3	96.1	30.2	8.2	19.2	22.0	-0.7	8.9
16	5.4	5.0	3.4	91.9	22.0	21.1	19.2	89.3	11.3	90.6	32.5	0.7	16.6	31.8	-5.2	5.9
17	21.2	20.0	17.5	85.5	31.2	28.9	25.5	78.7	21.5	82.1	53.3	16.8	35.0	36.5	12.9	3.9
18	26.8	24.9	21.6	80.2	36.3	33.3	29.3	76.2	25.5	78.2	64.0	24.0	44.0	40.0	20.2	3.8
19	38.2	32.6	24.7	57.9	40.0	36.2	31.7	72.6	28.2	65.3	75.6	31.0	53.3	44.6	25.8	5.2
20	31.6	27.8	21.5	65.7	58.5	42.8	23.9	26.4	22.7	46.0	66.0	29.5	47.8	36.5	22.0	7.5
21	26.0	25.1	23.6	90.4	29.4	27.8	25.3	84.4	24.4	87.4	29.3	25.4	27.3	3.9	22.0	2.4
22	25.8	25.0	23.7	91.4	40.0	36.5	32.4	74.7	28.1	83.1	41.8	24.5	33.2	17.3	20.0	4.5
23	28.5	27.3	25.4	88.0	34.0	32.5	30.5	87.0	27.9	87.5	52.0	25.2	38.6	26.8	20.6	4.6
24	24.0	23.2	21.7	90.9	54.6	41.0	24.1	30.8	22.9	60.8	65.2	20.0	42.6	45.2	18.0	2.0
25	23.4	22.5	20.7	89.7	19.6	19.3	18.7	96.2	19.7	93.0	27.0	†22.0	24.5	5.0	*22.0	0.0
26	-1.0	-1.0	-1.0	100.	8.0	8.0	8.0	100.	3.5	100.	29.0	-3.0	13.0	32.0	-8.3	5.3
27	12.5	12.5	12.5	100.	10.8	10.8	10.8	100.	11.7	100.	28.0	1.6	14.8	26.4	-3.6	5.2
28	12.8	12.8	12.8	100.	3.0	3.0	3.0	100.	7.9	100.	12.5	† 4.0	8.2	8.5	* 7.0	-3.0
29	6.7	6.7	6.7	100.	21.5	20.0	16.9	81.9	11.8	90.9	35.7	1.0	17.4	36.7	-5.0	4.0
30	34.4	27.8	15.8	45.7	31.0	29.0	26.0	81.3	20.9	63.5	54.0	11.2	32.6	42.8	11.6	-0.4
M	26.19	23.76	19.68	79.69	33.39	28.89	22.87	70.32	21.28	75.01	51.00	20.20	35.60	30.81	16.16	4.03

° Maximum temperature of day occurred between 7 p. m. and 7 a. m

† Minimum temperature of day occurred between 7 a. m. and 7 p. m.

* Reading at 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF NOVEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C		
25.203	25.176	25.189	....	....	......	....	n w	w	132.7	45.1	28.0	17.1	11.86	F
25.126	24.966	25.046	....	....	....	....	n w	w	114.2	......	......	......	......	F
24.858	24.761	24.810	....		......	....	n w	n	185.5	27.1	18.2	8.9	5.54	F
25.014	23.085	25.049	7:20a.m	8:45 a.m	.01	....	n	n	164.4	35.4	16.5	18 9	12.08	F
24.969	24.882	24.926	....	....	......	...	n	n w	100.7	36.0	18.1	17.9	11.54	Hv. F
24.878	24.889	24.883	Nt.	....	......	. .	s w	e	124.5	......	......	......	......	F
24.852	24.824	24.838	....	4:00p.m	.03	...	n e	n w	266.8	......	......	......	......	Lt sn
24.871	24.917	24.894	....	....	......	....	n w	n w	369.3	13.8	6.0	7.8	4.41	......
24.899	24.763	24.831	....	....	......	....	w nW	n e	356.9	31.0	16.0	15.0	9.41	......
24.653	24.999	24.826	....	....	......	....	w nW	s	494.0	43.4	25.2	18.2	12.40	......
25.048	25.074	25.061	....	....	.....	....	w	n w	153.5	......	......	......	......	F
25.080	25.014	25.047	....	....	......	...	θ	s w	117.0	47.7	31.8	15.9	11.30	......
24.978	24.811	24.895	.	.	T	.	s w	w	131.9	......	......	......	......	F
24.798	24.787	24.792	Nt.	....	......	....	s w	w	198.5	......	......	......	......	......
25.103	25.320	25.212	....	10:20am	.34	3	n e	n w	104.8	13.7	4.1	9.6	5.38	Sn
25.339	25.230	25.284	....	....	......	...	n	s w	101.8	39.0	14.1	24.9	16.00	F
25.279	25.204	25.242	....	....	......	...	n w	w	119.2	39.4	20.0	19.4	12.77	......
25.207	25.153	25.180	....	....	......	...	w	w	120.5	......	......	......	......	F
25.057	24.867	24.962		. .	. . . .	.	s e	0	137.2	......	......	......	......	......
24.758	24.806	24.782	....	....	......	. ..	n w	s w	166.8	......	......	......	......	F
25.089	25.078	25.083	. . .		. . . .	. .	s e	s e	106.8	......	....	......	......	......
25.164	25.281	25.223	....	....	......	..	w	s	91.6	......	......	......	......	F
25.152	24.920	25.036	....	....	......	....	e	w	68.0	......	......	......	......	......
24.764	24.602	24.683	Nt.	....	......	...	e	w	246.0	......	......	......	......	......
24.715	24.949	24.832	7:45a.m	2:30p.m	.29	3¼	e	w	75.7	.....	......	......	......	Sn
25.097	25.040	25.068	....	....	......	....	n w	e	81.4	......	......	......	......	......
24.909	24.966	24.938	....	....	......	....	s	e	98.1	......	......	......	......	......
24.971	25.207	25.089	....	....	T	....	s e	n	181.3	......	......	......	......	Sn
25.153	25.064	25.108	....	......	....	.	n w	n	103.0	...	....	......	......	......
24.850	24.920	24.885	. . ..	......	.....	..	w	s	291.2	.... .	......	......	......	......
24.994	24.985	24.990	....	....	0.67	6	......	......	166.8	33.78	18.00	15.78	10.24	......

‖ Use l to indicate approximate time.

TABLE 1.

METEOROLOGICAL RECORD AT AGRICULTURAL COLLEGE,

	TEMP., DEW POINT AND RELATIVE HUMIDITY								Daily Mean Dew Point	Daily Mean Relative Humidity	Maximum Temperature	Minimum Temperature	Daily Mean Temperature	Range	Terrestrial Radiation	
	7 A. M.				7 P. M.											
	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Dry Bulb	Wet Bulb	Dew Point	Relative Humidity							Instrument Reading	Radiation
	F°	F°	F°	Per Cent.	F°	F°	F°	Per Cent.	F°	Per Cent.	F°	F°	F°	F°	F°	F°
1	21.7	21.7	21.7	100.0	10.5	10.5	10.5	100.	16.1	100.	22.6	11.0	16.8	11.6	21.0	0.
2	4.0	4.0	4.0	100.0	8.0	8.0	8.0	100.	6.0	100.	10.0	3.4	6.7	6.6	3.2	0.2
3	18.0	13.6	-1.4	42.2	-5.0	-5.0	-5.0	100.	-3.2	71.1	31.0	-1.5	14.7	32.5	7.2	0.3
4	5.4	4.7	1.9	85.9	21.5	18.8	12.4	67.6	7.1	76.7	40.0	-7.6	16.2	47.6	-13.8	6.2
5	18.8	17.8	15.4	87.0	37.5	29.8	16.5	41.8	16.0	64.4	*51.6	7.0	29.3	44.6	3.0	4.0
6	29.0	23.8	12.8	50.3	29.1	27.1	23.9	80.4	18.3	65.4	*47.7	26.8	37.3	20.9	19.0	7.8
7	40.2	31.3	16.3	37.4	33.4	30.6	26.5	75.8	21.4	56.6	53.4	19.3	36.3	34.1	15.2	4.1
8	28.1	26.2	23.0	80.8	39.1	35.8	31.8	75.6	27.4	78.2	55.2	26.7	41.0	28.5	23.2	3.5
9	35.0	31.3	26.0	69.6	28.4	25.1	22.2	77.1	24.1	73.3	43.0	†28.3	35.6	14.7	†21.8	6.5
10	19.8	19.1	17.7	91.1	35.4	27.9	13.7	40.2	15.7	65.7	44.4	17.0	30.7	27.4	11.3	5.7
11	19.2	18.8	18.2	94.8	27.0	25.2	22.1	81.3	20.2	88.0	*45.3	17.8	31.6	27.5	11.0	6.8
12	32.3	31.8	31.1	95.5	33.0	25.7	10.2	38.1	20.6	66.8	42.2	25.0	33.6	17.2	22.6	2.4
13	24.2	19.8	9.1	51.8	26.2	23.2	17.3	68.7	13.2	60.3	38.9	†22.4	30.6	16.5	15.0	7.4
14	18.7	18.4	17.8	96.1	47.7	34.9	13.8	25.5	15.8	60.8	52.1	†17.3	34.7	34.8	15.0	2.3
15	17.0	16.0	13.4	86.3	4.0	3.6	2.0	91.5	7.7	88.9	17.3	† 3.0	10.2	14.3	-3.5	6.5
16	-8.8	-8.8	-8.8	100.	-1.0	-1.5	-3.8	86.8	-6.3	93.4	10.5	-10.8	-0.2	21.3	-15.3	4.5
17	-6.0	-6.0	-6.0	100.	5.0	4.6	3.0	91.8	-1.5	95.9	20.8	-9.8	5.5	30.6	-13.9	4.1
18	-5.2	-5.2	-5.2	100.	6.0	5.7	4.5	94.1	-0.3	97.0	25.2	†-6.0	9.6	31.2	-10.5	4.5
19	1.2	1.0	0.2	95.2	2.1	2.1	2.1	100.	1.1	97.6	21.2	-2.0	9.6	23.2	-7.0	5.0
20	-4.0	-4.0	-4.0	100.	8.0	7.6	6.2	92.6	1.1	96.3	29.1	†-5.8	11.7	34.9	-9.0	3.2
21	-4.8	-5.4	-8.7	81.4	11.6	10.8	8.2	87.0	-0.2	84.2	*33.3	-6.0	13.6	39.3	-10.8	4.8
22	26.8	22.5	13.3	56.5	34.2	28.2	17.8	50.1	15.5	53.3	46.8	6.0	26.4	40.8	1.9	4.1
23	15.9	15.2	13.4	90.1	25.7	24.3	21.8	84.9	17.6	87.5	48.3	15.7	32.0	32.6	10.0	5.7
24	13.8	13.2	11.5	90.9	28.0	25.7	21.7	76.8	16.6	83.9	51.5	12.7	32.1	38.8	8.4	4.3
25	15.3	15.3	15.3	100.	33.2	25.8	10.1	37.6	12.7	68.8	40.0	15.2	27.6	24.8	8.3	6.9
26	12.8	12.2	10.5	90.6	36.0	28.0	12.5	37.4	11.5	64.0	41.2	†12.2	26.7	29.0	† 6.3	5.9
27	21.3	20.2	17.9	86.7	34.4	29.2	20.7	56.8	19.3	71.7	47.0	†20.0	33.5	27.0	15.2	4.8
28	27.3	25.6	22.7	82.4	48.2	36.8	20.6	33.5	21.7	58.0	58.8	†25.1	42.0	33.7	20.0	5.1
29	46.9	36.1	20.6	35.0	44.7	32.7	11.0	25.2	15.8	30.1	63.0	40.2	51.6	22.8	29.9	10.3
30	45.0	32.0	6.1	20.2	29.1	25.9	20.2	69.2	13.1	44.7	47.3	†28.8	38.0	18.5	26.0	2.8
31	14.2	13.8	12.7	94.0	15.0	13.6	9.7	79.7	11.2	86.8	29.1	†14.0	21.6	15.1	5.8	8.2
M	17.52	15.35	10.92	80.38	23.74	20.05	13.30	69.91	12.11	75.14	38.96	11.79	25.37	27.17	7.63	4.77

† Minimum temperature of day occurred between 7 a. m. and 7 p. m.
* Maximum temperature occurred between 7 p. m. and 7 a. m.

The highest or lowest readings of the month are underlined.

TABLE 1—Continued.

FORT COLLINS, COLO., FOR MONTH OF DECEMBER, 1897.

Barometer, Corrected for Temperature and Instrumental Error.			PRECIPITATION				Direction of Wind		Total Movement 24 Hours Following 7 a. m.	ACTINOMETER				Frost or Dew
7 A. M.	7 P. M.	Mean	Time of Beginning	Time of Ending	Total Am't Rain and M'lt'd Snow	Av'g Depth of Snow	7 A. M.	7 P. M.		Black Bulb	Bright Bulb	Difference	Radiation	
Ins.	Ins.	Ins.			Ins.	Ins.			Miles	C	C	C	Cal	
24.917	24.901	24.909	8 a. m.	....	.12	2	s e	s e	158.3	......	......	......	......	Sn
24.919	25.095	25.007	....	....	.12	1	s	e	148.9	......	......	......	......	Sn
25.188	25.164	25.176	....	....	.12	1	n	......	158.9	......	......	......	......	Sn
25.029	25.155	25.092	....	....	......	....	s w	......	135.9	......	......	......	......	......
25.043	24.805	24.924	....	....	......	....	n w	s w	246.9	......	......	......	......	......
24.900	24.873	24.886	....	....	......	....	s w	w	168.9	37.5	16.8	20.7	13.36	......
24.759	24.905	24.832	....	....	......	....	w	w	171.3	38.3	19.3	19.0	12.42	......
24.718	24.721	24.720	7:15a.m	....	T	....	n	s w	175.7	28.7	16.1	12.6	7.84	F
24.916	25.018	24.967	....	Nt.	.21	Rn.	n w	s	171.9	22.4	10.4	12.0	7.13	R
24.982	25.078	25.027	....	....	......	....	e	w	182.7	16.2	8.4	7.8	4.49	F
25.039	24.784	24.912	....	....	......	....	n w	w	241.8	6.5	1.0	5.5	2.96	F
24.799	24.998	24.898	7 a. m.	....	T	...	n	n	375.0	......	......	......	......	Sn
25.060	24.919	24.990	....	....	......	...	n e	n w	141.4	30.9	12.2	18.7	11.56	......
24.635	24.439	24.537	Nt.	....	......	....	s w	w	223.4	......	......	......	......	......
24.496	24.820	24.658	....	‡ 9 a. m	.10	1½	e	s	243.7	Cl'dy	......	......	......	Sn
24.936	24.911	24.923	....	....	......	....	n	n w	86.0	27.9	3.0	24.9	14.70	F
25.068	25.055	25.062	....	....	......	....	n w	w	97.7	18.1	1.3	16.8	9.48	F
24 997	25.023	25.010	....	....	......	....	n	n w	85.3	30.1	6.8	23.3	14.07	F
24.951	24 827	24.889	‡10 a.m	....	T	....	n w	0	74 2	......	......	......	......	F
24.859	24.982	24.920	....	....	......	....	n e	n w	116.3	32.4	11.0	21.4	13.25	F
24.926	24.960	24.943	....	....	......	....	n	n w	100.5	21.0	0.8	20.2	11.51	F
25.035	25.146	25.090	....	....	......	....	w n w	w	197.2	33.1	17.1	16.0	10.15	.....
25 152	25.066	25.109	....	....	......	....	0	n w	58.7	36.1	18.4	17.7	11.43	.....
24.950	25.024	24.987	....	....	......	....	n	w	109.9	35.1	17.1	18.0	11.52	F
25.145	25.131	25.128	....	....	......	....	n w	n w	183.0	.....	......	......	......	F
25.149	25.116	25.131	....	....	......	....	n e	n w	242.1	.....	......	......	......	.....
25.146	25.130	25.138	....	....	......	....	s e	s w	127.2	14.0	5.5	8.5	4 80	.....
25.149	25.139	25.144	....	....	......	....	n w	n w	155.6	38.1	21.5	16 6	10 93	.....
25.172	25.092	25.132	....	....	......	....	n w	w	405.7	43.1	25.8	17.3	11.73	.....
24.983	25.297	25.140	11 a. m	....	T	....	w	n e	381.9	......	......	......	......	.....
25 548	25.435	25.492	7 p. m	....	......	....	n	s	168.7	27.5	8.2	19.3	11.60	.....
24.986	25.000	24.993	....	....	0.67	5½	......	......	178.5	28.26	11.62	16.65	10.26	......

‡ Used to indicate approximate time.

The monthly values of the observations detailed in the preceding table are summarised in table 2, following. Figures 12, 13, 14 and 15 go in connection with this table. It may be found suggestive to compare these values with the corresponding ones at the other stations given.

TABLE 2.

SUMMARY FOR 1897, AT AGRICULTURAL COLLEGE, FORT COLLINS, COLO.

Latitude, 40° 34'; Longitude, 105° West from Greenwich; Elevation of Barometer, 4,994 ft: of grounds 4,980 ft.

1897.	Mean Pressure Corrected for Temperature Only.	TEMPERATURE (IN DEGREES FAHRENHEIT).													Precipitation. (Rain or Melted Snow.	Snowfall	No. of Stormy Days	Relative Humidity	Dew Point	No. dys. Frost or Dew Obsv'd	
Month		Mean. ½ max+min	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Average Temp'rat'e Below 32°	Minimum Below 32°						Frost	Dew
	Ins.												No. of Days	No. of Dys	Ins.	Ins.	Ins.	per Ct.	F °		
n....	24.985	24.8	40.2	9.3	12.0	22.4	64.0	-26.0	30.9	51.8	10.5	17.7	22	31	0.18	2¼	2	68.4	6.6	13	
eb. .	24.852	27.6	40.9	14.2	16.9	28.1	59.5	-5.3	26.7	51.7	15.6	24.0	19	27	6.54	6¼	6	74.7	14.1	14	
arch .	24.806	32.3	44.8	19.9	25.3	32.7	65.3	-7.0	25.0	45.2	23.6	28.7	17	30	2.15	19½	9	72.6	19.8	13	.
pril ..	25.006	45.8	59.5	32.0	41.9	46.8	77.2	20.0	27.5	42.8	37.1	38.3	2	13	1.39	3¾	7	61.0	29.5	8	..
ay ...	25.035	58.1	73.6	42.7	56.2	59.5	82.3	31.6	30.9	43.5	49.9	51.0	0	1	2.06	....	13	63.0	44.6	2	8
une...	24.964	63.1	77.6	48.2	60.4	63.9	90.1	35.3	28.9	44.1	54.9	55.4	0	0	1.69	....	12	69.0	50.5	1	15
ly .	25.061	66.8	83.3	50.4	62.9	66.9	94.8	38.9	32.9	47.1	57.0	58.3	0	0	2.65	....	9	68.0	53.3	..	21
ugust	25.123	66.9	82.3	51.4	60.9	65.3	93.5	42.7	30.9	48.5	56.6	57.8	0	0	1.74	....	12	73.0	53.6	.	24
pt. ..	25.124	63.7	80.0	47.4	56.1	61.8	89.8	33.8	32.6	43.0	51.5	53.5	0	0	0.75	....	6	69.2	48.0	1	19
t . .	25.042	48.6	64.8	32.3	38.5	45.4	81.7	21.5	32.6	46.7	35.4	39.3	1	16	0.75	4	6	71.1	32.3	15	6
ov....	24.990	35.6	51.0	20.2	26.2	33.4	75.6	-3.0	30.8	50.6	23.8	28.9	9 .	27	0.67	6¼	4	75.0	21.3	12	..
ec....	24.993	25.4	39.0	11.8	17.5	23.7	63.0	10.8	27.2	47.6	15.4	20.0	19	30	0.67	5½	5	75.1	12.1	10	..
ear...	24.999	46.6	61.4	31.6	39.6	45.8	*94.8	*-26.0	29.7	*51.8	35.9	39.4	89	175	15.24	47½	9.1	70.0	32.1	89	93
orm'l	24.983	46.6	62.0	31.9	39.6	46.9	*99.2	*-28.4	30.1	*56.2	35.2	39.1	......	....	13.86	....	69.7	64.5	30.3		

* Extreme values.

§41. Figure 12 represents the precipitation by months, and shows both the rainfall for 1897 and the normal as obtained from observations extending over a large number of years, varying from 15 to 19 years for different months. The figures show clearly the preponderance of precipitation during the growing season. Each of the five months from April to August averages more than one inch of rainfall, and none of the other months have as much. Two-thirds of the rainfall of the year is received in these five months, and as this period, especially with the addition of March, includes practically all the growing season for fair crops, the importance of the distribution is evident. With this distri-

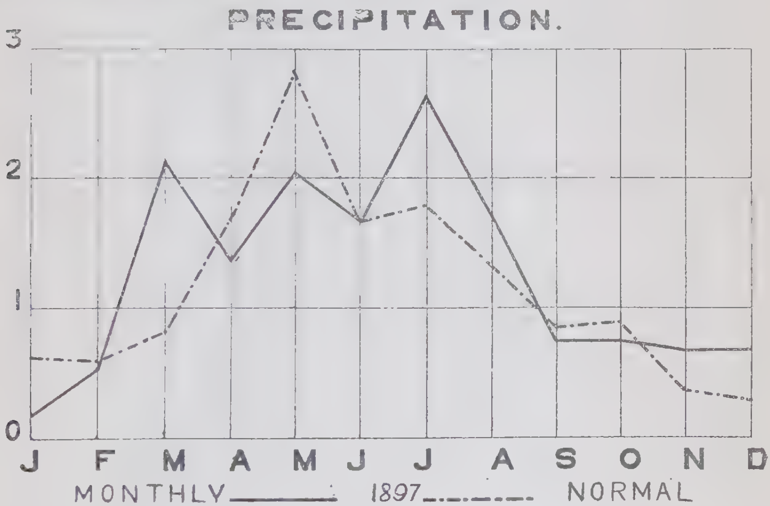


Fig. 12.

bution, the small amount of rainfall which we have is as effective as a much more abundant rainfall, but with a large proportion falling during the winter months.

§ 42. Every day on which enough rain falls to measure is included in the list of stormy days, and these are shown graphically in figure 13. The number of stormy days varies in nearly the same way as the amount of rainfall. While the precipitation in April exceeds that in March, the number of stormy days is less, which indicates that the amount received in each storm is greater in April. Likewise the storms in August average less than those in July.

§ 43. There is considerable range between the highest and lowest rainfalls recorded in any given month as is evident by inspection of table 5. The heavier, continued storms, lasting all day or extending through several days, occur principally in May, but the period when such storms are possible extend through April and forward into June. After this period the prevailing storms in the summer months are local thunder storms.

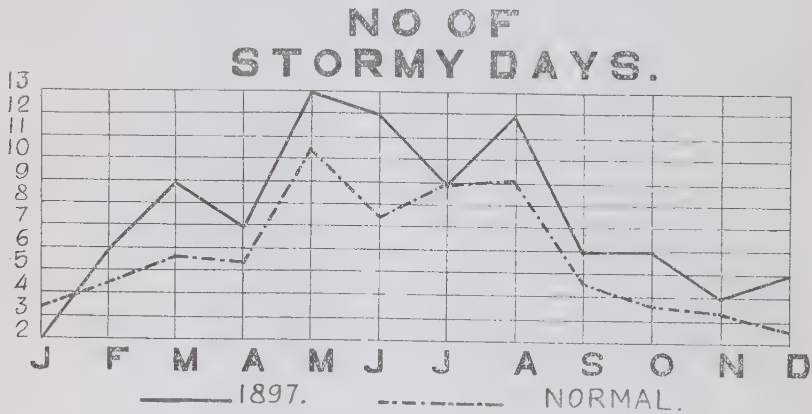


Fig. 13.

§ 44. Figure 14 shows the changes in temperature during the different months of the year as well as the average and the normal. The upper end of the line in any month indicates the highest temperature recorded during the month at any time, and the lower end indicates in a similar manner the lowest temperature during the month. The scale of temperatures is shown at the left side of the diagram. The length of the line thus shows the range during the month.

§ 45. The thicker portion of the line shows the limit of the temperatures on the average day. The upper ends of this portion, indicated by the cross line, show the average of the highest and lowest temperatures for each day through-

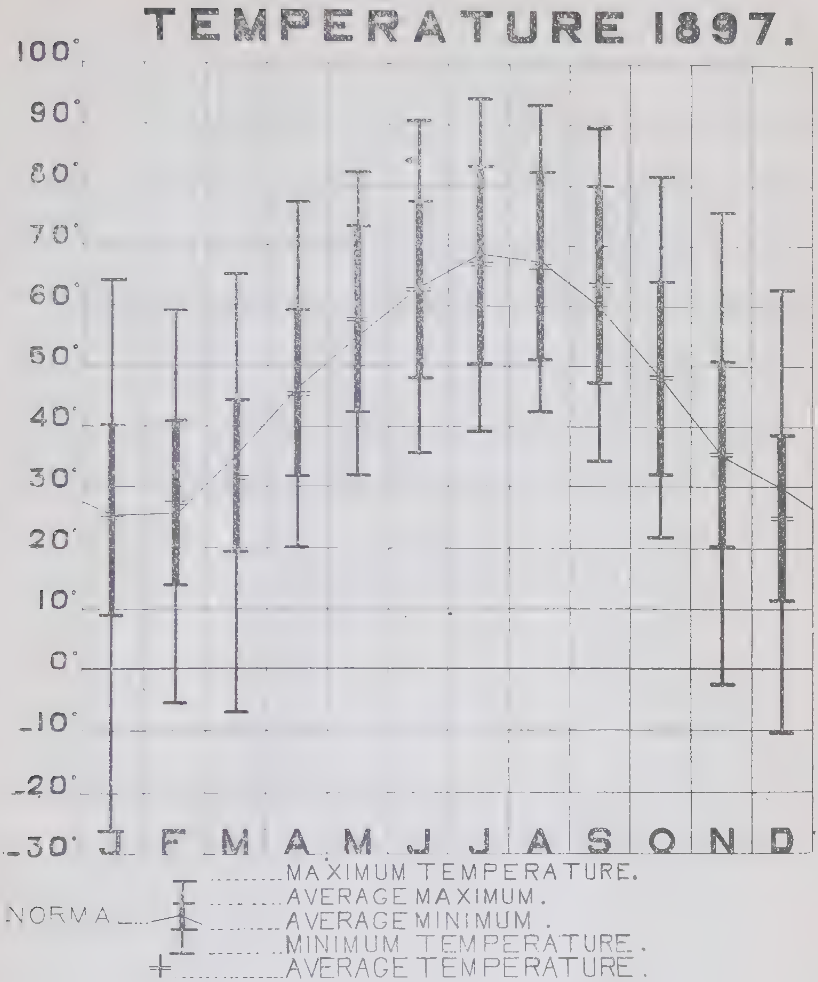

TEMPERATURE 1897.
100°
90°
80°
70°
60°
50°
40°
30°
20°
10°
0°
-10°
-20°
-30°
J F M A M J J A S O N D
MAXIMUM TEMPERATURE.
AVERAGE MAXIMUM.
NORMAL
AVERAGE MINIMUM.
MINIMUM TEMPERATURE.
AVERAGE TEMPERATURE.

Fig. 14.

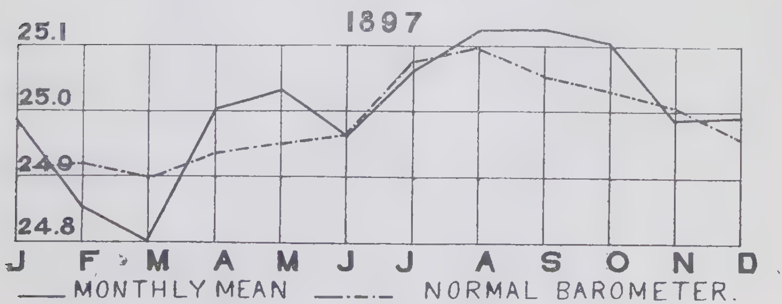

1897
25.1
25.0
24.9
24.8
J F M A M J J A S O N D
MONTHLY MEAN
NORMAL BAROMETER.

Fig. 15

out the month, and the double cross-line indicates the average temperature for the month.

§ 46. From the diagram, which puts in graphic form a portion of the summary given in table 2, it will be observed that the lowest temperature recorded during the year was in January and was 26° below zero, and that the highest temperature in the same month was 64°. For the 31 days of the month the maximum temperatures of each day averaged 40° and throughout the month the minimum temperature descended on the average to 9°. The temperature fell below zero in five different months and rose above 90° in three months. The greatest range in any single month is in January when the range was from 26° below zero to 64° above, or an absolute range of 90°. The range during the year was 120°.

§ 46. The same diagram shows the average monthly temperatures for 1897 by two short cross-lines and the normal by the full line crossing the vertical lines. As shown by the diagram both January and February were warmer than the average, March was cold, May warm and September unusually warm. April is nearer the average temperature of the year than any other single month, October is slightly above the yearly average, and the mean of April and October is close to the average of the year.

§ 47. The monthly mean barometer, as shown in fig. 15, requires little comment. The variation during 1897 was greater than the normal, February and March being below, while the two succeeding months, as well as August, September and October are above the normal.

Though the barometer is one of the most important instruments for one observing the weather, and wishing to be forewarned of impending changes, it is one of the most useless to the agricultural meteorologist. Not that it is not of some value, for the rise of water in soils, the flow of water in drains, the increase of seepage water, and the numerous important fluctuations, all show a connection with the changes in the barometer, but as a whole the connection with the phenomena of most importance in plant growth is obscure and not likely to be of value to other than the scientific student or the professional meteorologist. Many who are interested in meteorological observations have the impression that a barometer is one of the most necessary instruments and that no observations of value can be made without it. So far is this from being true that to most people it is of little use, and a small part of the expense re-

quired for a barometer will purchase a good set of thermometers and a rain gage which, systematically observed, will yield useful climatic data.

SUB-STATIONS.

The observations at Cheyenne Wells and at Rocky Ford are not given in detail, but are summarised in tables 3 and 4. The conditions of exposure are not so good as at Fort Collins. The averages and the reduction to determine the dew point and relative humidity from the observations are computed at the home station at Fort Collins. For a portion of the year the wet and dry bulb thermometers observed at the Cheyenne Wells station were obtained from other sources than through the home station, and it was subsequently found that the thermometers were in error, and the corresponding relative humidities and dew points are incorrect.

TABLE 3.

SUMMARY FOR 1897, AT ROCKY FORD SUB-STATION.

P. K. BLINN, OBSERVER JANUARY TO JUNE, W. F. CROWLEY, FROM AUGUST.

Latitude 39° 3′. Longitude 103° 45′; Elevation 4,160 feet

Month.	TEMPERATURE (IN DEGREES FAHRENHEIT.)													Precipitation. (Rain or Melted Snow)	Total Snowfall	Number of Stormy Days	Relative Humidity Mean	Dew Point Mean	No. dys. Frost or Dew Obsv'd		Prevailing Direction of Wind
	Mean	Av. Maximum	Av. Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32°	Minimum Below 32°						Frost	Dew	
	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	No. dys	No. dys		Ins		Per Ct.	F°			
Jan....	25.9	38.4	13.3	19.1	28.9	54.0	-15.	25.1	36.0	18.1	27.0	19	31	0.75	5	1	84.7	20.0	.	..	n w
Feb....	34.8	48.1	21.4	28.1	35.6	65.0	0.0	26.7	46.0	25.8	31.6	9	28	0.37	2	2	73.8	23.6			w n w
March.	39.8	56.0	23.5	31.8	44.2	74.0	7.0	32.6	50.0	28.5	37.4	7	25	0.20	....	1	65.0	25.8	..	..	s
April..	50.1	67.1	33.2	45.6	52.8	85.0	20.0	33.9	51.0	40.7	43.7	0	12	0.44	...	2	60.3	34.4			n e
May...	....	....	....	....	....	....	....	..	....	..	. .	...	....	....	....	..	...	...			..
June...	...	....	....	....	....	....	....					....	....	....	...						......
July...	....	....	....	....	....	....	....	....	....	....	....	..	..		.	.	..			..	....
Aug....	† 70.2	† 87.5	† 52.8	* 64.3	* 71.3	99.0	46.5	34.9	47.5	59.7	61.7	0	0	0.73	...	5	* 68.5	* 55.9		10	e
Sept..	69.3	85.6	53.0	‡ 60.8	‡ 70.1	97.5	42.0	32.7	41.5	‡ 56.9	‡ 61.7	0	0	0.79	.	2	‡ 68.1	‡ 54.9		8	s e
Oct....	54.0	68.9	39.1	45.8	53.7	87.5	24.0	29.8	48.5	40.5	45.7	1	6	2.64	4	4	67.8	37.3	12	3	n w
Nov....	41.7	59.5	23.9	29.5	40.8	80.0	10.0	35.6	57.0	26.8	34.1	2	26	0.19	½	1	65.6	23.4	17		n n w
Dec....	26.7	41.3	12.1	19.3	25.3	74.0	-8.0	29.1	50.0	17.1	22.7	24	30	1.06	6.8	3	74.7	14.7	15	..	n n w
Sums	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	....
Av.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..	..	....

TABLE 4.

SUMMARY FOR CHEYENNE WELLS SUB-STATION.

J. E. PAYNE, OBSERVER.

Latitude 38° 50′; Longitude 102° 20′; Elevation 4,278 feet.

Month	TEMPERATURE													Precipitation. (Rain or Melted Snow	Total Snowfall	No. Stormy Days	Relative Humidity	Dew Point Mean	No. Dys Frost or Dew Obsv'd		Average Cloudiness	Prevailing Direction of Wind
	Mean ½ Maximum	Average Maximum	Average Minimum	7 A. M.	7 P. M.	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Wet Bulb 7 A. M.	Wet Bulb 7 P. M.	Av. Temp. Below 32°	Minimum Below 32°						Frost	Dew		
	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	F°	No. Days	No. Days	Ins	Ins		Per Ct.	F°				
Jan....	25.9	38.2	13.7	20·0	21.7	60.6	-12.	24.5	41.0	18.2	19.5	17	31	0.26	....	2	78.5	14.6	13	..	3.4	n w
Feb..	31.7	45.8	17.6	24.8	28.7	63.4	9.0	28.2	49.5	23.6	24.8	13	28	0.10	1	1	75.5	19.0	7	..	4.3	n w
March..	35.2	48.5	22.0	‡ 29.4	‡ 35.8	69.6	6.6	26.5	39.6	‡ 28.3	‡ 31.8	10	26	1.58	9	4	‡ 79.3	‡ 26.2	7	..	4.2	s
April..	48.0	61.9	34.1	45.3	48.6	81.8	26.0	27.8	45.2	....	....	0	12	1.20	T	7	....	....	6	1	3.7	n n e
May ...	62.0	76.7	47.2	58.2	63.5	92.2	37.0	29.6	44.0	....	...	0	0	1.44	....	5	....	....	..	4	5.8	s e
June...	68.9	84.7	53.2	65.5	69.3	97.6	43.0	31.5	41.1	....	...	0	0	2 22	....	11	....	....	..	..	5.0	s e
July..	74.1	89.8	58.4	71.9	75.5	102.6	47.6	31.4	41.2	....	....	0	0	4.21	...	5	....	....	..	1	3.0	s
August	70.0	83.2	56.7	67.1	70.6	96.0	51.0	26.6	39.0	....	....	0	0	3.24	....	7	....	....	..	8	3.4	s e
Sept...	69.0	84.2	53.8	63.8	69.3	96.0	37.2	30.4	43.0	....	....	0	0	0.92	T	2	....	....	..	1	2.4	s
Oct....	53.6	67.4	39.8	46.8	50.9	88.0	21.0	27.6	44.2	...	....	1	7	2.73	3	6	....	....	5	2	....	w
Nov....	39.8	56.0	23.6	32.1	34.0	79.2	3.2	32.3	47.2	....	....	8	25	0.10	1	1	....	....	13	..	3.3	w n w
Dec....	26·6	38.9	14.3	21.8	22 9	64.0	-9.8	24.6	45.0	....	....	16	31	0.20	2	2	....	....	2	..	4.0	n w
Av.	50.4	61.6	36.2	45.6	49.2	.....	....	28.4	....	....	....	5.4	13.	1 52	....	4	....	....	..	..	....	......

‡ Record lacking from the 14th to 22d.

§49 The corresponding summaries from three of the volunteer observers are given in the three following tables, these stations being Lambs, Estes Park P. O., at an elevation of 9,000 feet: Geo. A. Barnes, Pinkhampton, at an approximate elevation of 8,400 feet, and Mrs. Sherwood, Gleneyre P. O., at an elevation of 8,000 feet. Their location is further described in section 54.

The instruments have in most cases, been furnished by the Experiment Station or have been compared with our instruments.

§50 An interesting comparison may be made between the records at the different elevations, especially between those at the foot of Longs Peak and at Fort Collins. The distance in an air

line, is 35 miles, and the difference in elevation is 4,000 ft. The higher station has an average temperature for the year over 9° colder than Fort Collins. In the summer, from May to September inclusive, the mountain station averages 13° colder, while during the winter months of January, February and March, it averaged but 6° colder. It was, therefore, relatively warmer during the winter than during the summer.

§51 If the records are compared day by day, it is noticeable that the temperature at the higher station is often higher than at Fort Collins during the winter months, and this notwithstanding 4,000 feet difference of elevation. When first noticed some years ago, some doubt was felt as to the reality of the phenomena. Continued observation has not only confirmed it, but shown that in the winter months from December to April, it is very common. In some years the average temperature at the higher station has actually been above that at Fort Collins during the winter months. Such inversions of temperature have been observed between Denver and the summit of Pikes Peak.

§52 Many of the differences are due to the fact that the cold waves which sometime reach us in the winter from the north, consist of a wave of cold air, relatively shallow, which underruns the layer of warmer air, displacing it, and the cold wave is not in itself deep enough to reach up to the mountain stations and submerge them in its wintry bath. When the cold is due to local radiation, as when the ground is covered by a thin layer of snow, then the temperature at the mountain stations descends lower than on the plains.

TABLE 5.

SUMMARY AT MR. CARLYLE LAMB'S AT THE BASE OF LONG'S PEAK, ESTES PARK POSTOFFICE. ELEVATION, 9,000 FEET,

MONTH	Mean Temperature	Average Maximum	Average Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	Average Below 32°	Minimum Below 32°	Precipitation	Snowfall	Stormy Days
January	23.8	35.4	12.3	54	– 14	23.1	....	....	....	.40	8	....
February	19.1	29.7	8.6	48	– 10	21.1	33	26	28	1.20	19	7
March	22.6	33.0	12.3	53	– 11	20.7	35	22	31	1.96	24	5
April	32.5	43.1	21.9	60	1	21.2	38	13	27	1 35	18	8
May	45.0	57.9	32.2	68	23	25.7	35	0	14	1.60	4	3
June	49.6	62.5	36.7	74	26	25.8	34	0	2	1.50	1	5
July	54.7	67.7	41.6	78	32	26.1	37	0	0	1.85	0	5
August	53.5	63.5	43.6	75	22	19.9	39	0	0	1.29	0	8
September	50.5	66.2	34.8	75	28	31.4	37	0	3	0.95	0	4
October	39.6	53.2	26.1	67	2	27.1	39	6	24	1.10	9	4
November	34.2	44.7	23.7	72	– 4	21.0	44	14	21	.55	12	4
December	22.6	33.1	12.0	48	– 9	21.1	41	25	30	.25	5	4
Year	37.3	49.2	25.5	..	....	23.7	....	....	....	14.00	100	..

TABLE 6.

SUMMARY AT MR. GEO. A. BARNES', PINKHAMPTON, COLO. ELEVATION 8,400 FEET.

MONTH	Mean Temp. ½ (7 a.+7 p.)	Av. Temp. 7 a. m.	Av. Temp. 12 m.	Av. Temp. 7 p. m.	Highest Temp. 12 m.	Lowest Temp. 7 a. m.	Mean Range	Greatest Range 7 a. m. to 12 m.	No. of Days Averaging Below 32°	No. of Days Minimum Below 32°	Precipitation	Snowfall	No. of Stormy Days
	F °	F °	F °	F °	F °	F °	F °	F °			Ins.	Ins.	
January	11.6	6.8	29.7	16.5	50	–17	25 1	44	31	31	1.50	15	6
February	16.3	12.5	34.5	20.2	52	– 7	28 9	42	28	28	1.35	13½	8
March	19.8	15.3	39.3	24.2	65	– 9	24.9	42	28	30	2.20	22	7
April	33.3	26.5	53.8	40.0	81	2	27.5	51	12	22	1.95	19½	10
May	47.7	38.5	68.4	56.9	82	29	30.0	47	0	1	2.06	....	6
June	53.0	43.9	69.1	62.0	83	33	26.0	45	0	0	2.62	2	14
July	55.6	46.6	75.9	64.5	86	37	29.9	43	0	0	2.41	....	14
August	55.9	44.6	79.2	67.2	87	36	34.8	51	0	0	1.38	....	12
September	52.6	42.2	73.2	62.9	84	28	31.0	46	0	2	.35	....	7
October	36.5	30.3	57.0	42.7	78	5	26.8	52	9	14	.45	1	8
November	26.5	26.6	44.8	26.4	68	10	20.9	44	15	18	1.10	11	5
December	15.5	12.6	27.5	18.4	49	–24	19.4	38	29	29	2.00	20	9
Year	35.4	28.9	54.4	41.8	..	..	26.7	..	152	175	19.37	104	106

TABLE 7.

SUMMARY AT GLENEYRE P. O., MRS. F. W. SHERWOOD, OBSERVER, NEAR THE HEAD OF THE LARAMIE RIVER. ELEVATION, 8,000 FEET.

MONTH	Av. Temp. 7 a. m.	Av. Temp. 2 p. m.	Av. Temp. 9 p. m.	Mean Temp. ½ (Max+Min)	Av. Maximum	Av. Minimum	Absolute Maximum	Absolute Minimum	Mean Range	Greatest Range	No. Days Av. Below 32°	Days Minimum Below 32°	Precipitation Inches	Snowfall	No. of Stormy Days
January	12.8	27.8	16.4	16.5	29.7	3.2	47	-18	26 5	38	29	31	1.00	10	4
February	15.0	25.4	16.8	17.8	26.4	9.2	43	- 8	17.2	33	28	28	.70	10½	6
March........	18.9	27.6	20.5	22.0	31.4	12.7	52	-10	18.7	42	27	31	2.90	28	4
April.........	24.5	41.1	28.7	31.4	42.8	19.9	67	- 5	22.9	40	15	27	†2.00	† 24½	† 8
May	41.4	58.3	41.0	47.2	60.0	34.5	70	27	25.5	39	0	8	.30	......	2
June	47.6	63.8	46.2	51.1	67.2	35.0	83	23	32.2	50	0	5	.50	......	7
* July	53.5	67.2	52.4	56.0	69.5	42.6	82	33	26.9	44	0	0	......	......	2
August	52.0	68.1	51.1	56.6	71 3	41.8	78	33	29.5	40	0	0	......	......	8
September ..	......	......	......	......	......	....	......	.....	......	....	..	....	......	......	....
October	32.9	48.1	34.7	37.8	49.5	26.0	64	1	23.5	38	8	22	1.20	12½	6
November...	30.5	41.1	29.9	32.4	42.9	21.9	66	2	21.0	46	13	24	.50	11	10
December	16.3	23.6	16.2	15.8	25.1	6.6	48	16	18.5	38	29	31	1.65	16½	11
Year. ...	......	......	......	......	......	....	83	-18	......	....	....	...	......	......	...

* Records lacking for first twelve days.

† No record of precipitation after the 12th, owing to absence.

PRECIPITATION.

§ 53 From a number of places precipitation and other records have been furnished by volunteer observers who have been furnished with instruments from this station These stations have been selected in most cases for the purpose of obtaining a record of the precipitation in the mountains which form the water shed of the adjacent rivers. As the Cache a la Poudre river has been the subject of investigations for a number of years and records have been maintained of its flow, it has been desired to study the amount and distribution of the precipitation on its water shed. We have not received reports from as many observers this year as formerly.

§ 54 Of the stations noticed in the following table, the first five are situated in the mountains and the last five on the plains.

Pinkhampton is located on the eastern border of North

Park at an elevation of 8,400 feet. It is situated to the west of the range whose eastern slope forms the water shed of the Laramie and of the Cache a la Poudre rivers. Mr. G. A. Barnes has been the observer and has also kept a record of temperature.

The station in Estes Park has been kept by Mr. Carlyle Lamb, living at the foot of Longs Peak to the south of the park proper, but situated almost on the divide between the waters which flow into the St. Vrain on the south and the Big Thompson on the north. This station is in a mountain valley extending north and south. To the east the Twin mountains, within less than two miles, rise to a height of about 11,500 feet, while to the west, within four miles, Longs Peak reaches an elevation of 14,271 feet. Mr. Lamb is a close observer and has taken great interest in other observations as well as in these particular ones. He has kept a record of the rainfall as well as of temperature for a number of years.

Gleneyre is situated twenty miles east of Pinkhampton, on the opposite side of the high range of mountains which forms the northeast rim of North Park. It is situated on the Laramie river which runs nearly north and south, and is separated on the east side by a lesser range of mountains from the water shed of the North Poudre. It is, therefore, protected from winds from all directions except the north. The influence of the mountains is shown in the decreased rainfall noticed. The elevation is about 8,000 feet. Mrs. F. W. Sherwood has been the observer.

§ 55 At Westlake Mr. S. J. Peery has been the observer. This place is located about twenty miles southeast of Gleneyre and a few miles north of Manhattan near the Cache a la Poudre river. The elevation is about 8,500 feet.

Water Dale, Arkins P. O., is the home of Mr. P. H. Boothroyd. It is on the banks of the Big Thompson river at the junction of the foot hills with the mountains. It is situated about twelve miles south and as many west of Fort Collins. The elevation about 5,500 feet.

Loveland is 13 miles south of Fort Collins in the valley of the Big Thompson creek. Rev. W. H. McCreery has been the observer for some years. Elevation 5,000 feet.

LeRoy is located in the valley of the Platte a little over 100 miles east of Fort Collins, and nearly 50 miles west of the eastern border of the state. Mr. C. J. Green has carried on the observations at this place for a number of years with much interest.

TABLE 8.

PRECIPITATION, 1897.

	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Year
Pinkhampton....	1·50	1.35	2.20	1.95	2.06	2.62	2.41	1.38	0.55	0.45	1.10	2.00	19.57
Estes Park	1.55	1.20	1.96	1.35	1.60	1.50	1.85	1.29	0.95	1.10	0.55	0.25	15.15
Gleneyre....	1.00	0.70	2.90	‡2.00	0.50	0.20	0.40	0.30	.....	1.20	1.60	1.65	......
Westlake.......	T	0.88	4.70	......	1.80	......	......	.....	......	......	......	....	......
Waterdale..... .	0.18	0.50	2.32	1.82	3.61	2.30	2.42	1.09	0.84	1.07	0.82	0.64	17.61
Fort Collins.....	0.18	0.54	2.15	1.39	2.06	1.69	2.65	1.74	0.75	0.75	0.67	0.67	15.24
Loveland........	0.15	0.54	1.98	0.94	1.21	......	......	......	0.39	......	0.59	0.63	......
Rocky Ford.....	0.75	0.37	0.20	0.44	......	......	......	0.73	0.79	2.64	0.19	1.06	......
Cheyenne Wells..	0.26	0.10	1.58	1.20	1.44	2.22	4.21	3.24	0.92	2.73	0.10	0.20	18.20
Leroy............	0.60	0.72	1.66	1.77	3.98	2.24	1.39	2.79	0.41	2.61	0.40	0.81	18.48

‡ The record incomplete until the 12th, rest of month lacking.

SOIL TEMPERATURES.

§ 56. The weekly averages of soil temperatures down to depths of six feet are shown in tables 2 and 10 and are represented graphically in figure 16.

§ 57. Two sets of thermometers have been in use during the year. Set A in the instrument plat on the lawn west of the engineering building, where they were placed Jan. 15, 1897, and set C on a high knoll near the college barn. The exposure for set A was nearly the same as at the former location, a removal from which became neces- by the construction of the new chemical laboratory. The surface of the ground was covered with grass, but was subject to inundation when the adjacent lawn was irrigated. This was considered a serious drawback to the location, but afterwards resulted in an unique illustration of the effect of irrigation on soil temperature, which is mentioned later.

§ 58. The temperature of the soil varies according to the character and color of the soil, the kind of covering and the exposure to the heat of the sun, as well as to a number of accidental influences. Those soils spoken of, especially in the East, as early, owe their character principally to their greater temperature, which accelerates the germination and growth of the plant.

§ 59. Figure 16 shows the averages of set A by weeks

throughout the year. The shallow temperatures, even when smoothed by using the weekly averages, show much greater variations than the deeper ones. Some time is taken for the surface temperature to affect the lower thermometers. Practically the daily variation disappears before reaching a depth of six feet, and the daily change does not often exceed one or two-tenths of a degree. The heat wave moves slowly through the soil, so that while the highest temperature of the day is reached at a depth of three feet at nearly the same hour as at the surface, its temperatures correspond to those of the day before. This cannot be seen in the present diagram. The curves do, however, especially in the winter, show the lagging of the annual curve of temperature. Examining the curves of the three deeper thermometers, it will be seen that they reach the lowest temperatures at different periods, one at six feet about three weeks behind the one at three feet. It is about six weeks behind the surface temperature, though in this case the accidental and short period variations mask the annual curve at the surface. During the summer there is a corresponding lagging of the highest temperatures at the greatest depths, though the normal curve is altered by the irrigations to which the ground where the thermometers were placed was subjected.

TABLE 9.

WEEKLY MEANS OF SOIL TEMPERATURES SET A, 1897.

WEEK ENDING	DEPTH 3 In.	6 In.	1 Ft.	2 Ft.	3 Ft.	6 Ft.	WEEK ENDING	DEPTH 3 In.	6 In.	1 Ft.	2 Ft.	3 Ft.	6 Ft.
Jan. 2....	28.20	30.08	32.07	34.74	38.24	44.69	July 10.	69.32	69.44	69.33	67.91	66.91	62.30
Jan. 9.....	24.40	27.04	30.09	33.61	37.45	43.95	July 17...	69.86	69.98	69.84	68.10	66.97	62.24
Jan. 16:....	27.50	29.16	30.99	33.43	36.86	43.33	July 24...	66.63	67.11	67.63	67.09	66.53	62.24
Jan. 23.....	29.06	29.81	31.03	33.84	37.14	44.16	July 31...	69.13	69.16	68.94	67.32	66.32	62.16
Jan. 30.....	23.56	25.36	27.99	33.17	36.61	43.64	Aug. 7..	69.25	69.54	69.46	67.79	66.71	62.19
Feb. 6.....	28.71	29.34	30.06	32.52	36.04	43.21	Aug. 14..	70.99	71.50	71.60	70.04	68.44	63.81
Feb. 13.....	32.04	30.80	31.11	32.60	35.83	42.68	Aug. 21..	68.37	69.87	71.54	72.41	72.26	68.43
Feb. 20.....	29.72	30.27	30.79	32.73	35.79	42.40	Aug. 28..	67.48	68.32	69.24	69.85	70.49	67.96
Feb. 27...	27.91	28.93	30.11	32.74	35.69	42.07	Sept. 4.	70.16	70.74	70.57	69.51	69.44	67.16
March 6...	31.36	31.31	31.48	32.64	35.55	41.67	Sept. 11..	68.88	69.76	70.18	69.69	69.39	66.71
March 13..	31.73	31.84	31.84	32.79	35.53	41.47	Sept. 18.	64.09	65.56	66.80	67.69	68.16	66.36
March 20...	32.12	31.43	31.96	32.98	35.56	41.22	Sept. 25.	62.82	63.69	64.47	65.14	66.09	65.73
March 27...	33.39	32.87	32.02	33.27	35.74	41.09	Oct. 2...	62.60	63.49	64.28	64.63	65.39	65.00
April 3....	35.94	35.69	33.87	34.36	36.38	41.09	Oct. 9...	57.62	59.14	60.77	62.64	64.07	64.43
April 10..	39.26	39.74	38.82	37.33	38.14	41.32	Oct. 16.	52.75	54.23	56.38	59.28	61.62	62.64
April 17....	46.77	46.89	45.12	41.71	41.04	41.96	Oct. 23...	47.12	48.65	51.14	55.37	58.58	62.44
April 24....	50.69	50.97	49.91	46.51	44.84	43.20	Oct. 30...	44.15	45.59	48.04	52.55	55.87	61.05
May 1.....	53.03	53.22	52.16	48.91	47.40	44.79	Nov. 6..	41.34	43.01	45.19	49.48	53.08	59.53
May 8.....	57.07	57.04	56.15	51.91	49.68	46.36	Nov. 13..	40.79	41.75	43.30	47.01	50.76	58.01
May 15.....	57.48	57.65	56.94	53.95	52.04	47.85	Nov. 20..	39.39	40.26	42.39	46.19	49.56	56.59
May 22.....	61.23	61.11	59.84	56.14	53.84	49.27	Nov. 27..	37.53	33.60	40.72	44.48	47.99	55.49
May 29.....	62.17	62.27	61.71	58.39	56.09	50.52	Dec. 4...	33.12	34.09	26.75	41.70	46.03	54.25
June 5....	58.70	59.20	59.63	58.21	56.84	51.94	Dec. 11...	32.53	32.28	35. 8	39.71	43.99	52.98
June 12....	60.38	60.36	59.90	57.76	56.74	52.81	Dec. 18...	31.31	32.26	34.46	38.78	42.86	51.77
June 19.	65.33	65.17	66.30	65.25	64.61	60.74	Dec. 25.	27.57	28.17	30.87	36.16	40.78	50.53
June 26....	70.20	70.44	70.31	68.59	66.87	62.60	1898 — Jan. 1....	29.66	30.19	31.32	35.08	39.49	49.40
July 3.	70.27	70.24	70.06	68.20	67.06	62.44	Average..	48.35	48.99	49.68	50.45	51.72	53.49

TABLE 10.

WEEKLY READINGS (NOT AVERAGES) OF SOIL THERMOMETERS, SET C, 1897, (ON UNIRRIGATED GROUND.)

WEEK ENDING	DEPTH				WEEK ENDING	DEPTH			
	6 In.	1 Ft.	2 Ft.	3 Ft.		6 In.	1 Ft.	2 Ft.	3 Ft.
January 7	28.1	29.0	33.5	35.9	July 1	68.5	66.2	62.6	59.5
January 14	29.7	29.9	33.3	35.2	July 8	66.9	66.1	63.7	60.3
January 21	28.8	29.1	32.8	34.8	July 15	68.5	66.1	64.2	61.3
January 28	22.9	25.1	31.3	34.0	July 22	67.1	65.1	63.5	61.1
February 4	27.8	28.1	30.8	32.6	July 29	69.0	66.7	64.3	61.7
February 11	29.6	29.8	32.2	33.3	August 5	68.0	67.0	65.2	62.8
February 18	30.2	30.2	32.3	33.5	August 12	69.1	67.1	65.4	62.9
February 25	28.2	29.0	32.3	33.8	August 19	66.2	65.1	65.2	63.3
March 4	31.2	31.1	32.8	33.7	August 26	68.0	66.1	64.5	62.6
March 11	32.2	32.6	33.9	34.4	September 2	68.0	66.1	64.8	62.8
March 18	32.7	32.5	33.8	34.5	September 9	68.1	67.1	65.6	63.6
March 25	33.2	33.2	34.8	35.3	Septemqer 17	60.2	61.0	63.3	62.9
April 1	35.1	35.5	37.3	36.8	September 23	61.9	61.2	61.8	61.1
April 8	38.7	37.8	38.3	37.6	September 30	62.8	61.6	61.8	60.8
April 15	44.6	43.1	40.8	39.2	October 8	58.2	58.7	60.0	59.8
April 22	48.2	46.5	44.8	42.5	October 16	51.7	53.6	56.8	57.2
April 29	51.0	49.7	47.8	45.0	October 21	48.2	49.1	53.4	55.1
May 6	56.5	53.6	50.7	47.4	October 28	44.2	45.7	51.0	52.8
May 13	56.4	54.5	52.4	49.7	November 4	43.3	44.5	48.3	50.3
May 20	59.2	57.4	53.9	51.5	November 12	43.2	42.6	45.8	47.7
May 27	60.0	59.4	57.2	53.6	November 18	38.7	40.3	45.0	47.1
June 3	57.4	57.1	56.8	54.4	December 9	34.6	35.6	39.8	42.3
June 10	60.8	58.8	56.7	54.3	December 16	32.7	34.1	37.8	41.1
June 17	64.0	62.1	59.6	56.3	December 23	26.1	27.7	34.2	38.3
June 24	67.2	65.1	61.6	58.0	December 30	31.2	31.3	34.2	36.6
					Average	48.76	48.32	49.08	48.65

§60. The dates of the highest and lowest temperatures for the different years, and the observed temperatures are shown in table 11. Considerable variation is shown in the dates of the highest temperature, partly in the case of the deeper depths especially from the effect of flooding from irrigation waters. The date of minimum is less subject to extraneous influences. As the temperatures are observed at 7 a. m. and 7 p. m. only, the highest and lowest temperatures of the day of the shallow thermometers are not not observed and the diurnal variation would slightly affect these readings. For the deeper thermometers the diurnal fluctuation is very small.

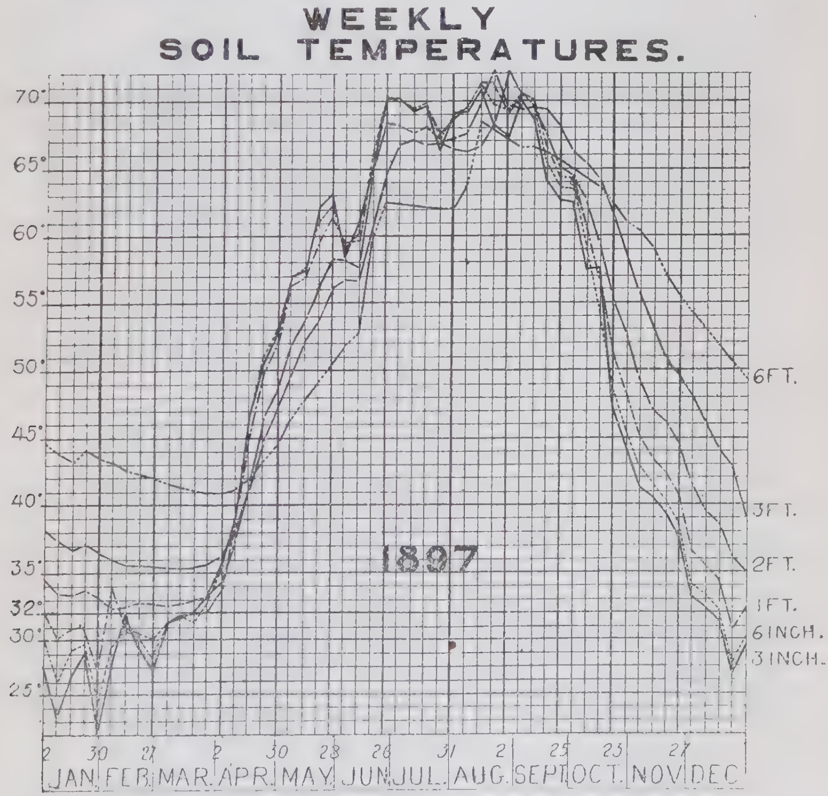


Fig. 16

TABLE 11.

DATES OF EXTREME TEMPERATURES AT DIFFERENT DEPTHS FROM READINGS AT 7 A. M. AND 7 P. M.

Year	DEPTH											
	3 INCHES				6 INCHES				12 INCHES			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	June 30..	87.7	Jan 9....	16.0	July 1...	81.2	Jan 9....	21.0	June 30....	76.8	Jan 21-22..	26.0
1890	July 1....	86.2	Jan 2....	14.5	July 1...	81.2	Jan 2....	20.0	July 16....	72.5	Jan 24.....	25.5
1891	July 24 ..	84.0	Feb 9....	17.8	July 11..	80.6	Feb 10...	21.9	....	....	....	....
1892	Aug 14...	84.2	Jan 13...	16.3	Aug 14...	80.8	Jan 11...	20.7	Aug 15	72.5	....	....
1893	June 28 to July 4	87.5	Jan 18...	21.3	July 5...	83.9	Jan 18...	26.0	July 5.....	76.1	Jan 21.....	30.3
1894	June 12..	78.6	Dec 28...	14.7	July 27..	76.1	Dec 28...	21.4	July 27....	71.5	Dec 28.....	24.3
1895	July 6 ...	83.2	Jan 15...	8.5	July 6...	78.8	Jan 15...	13.0	July 29....	71.6	Jan 15.....	19.2
1896	July 13 ..	90.8	Jan 4....	18.8	July 13..	86.1	Jan 4....	22.7	July 13....	77.1	Jan 4......	27.9
1897	July 7 ...	78.2	Jan 5....	18.9	Aug 12...	77.3	Jan 5....	23.9	Aug 12.....	77.0	Jan 5......	29.5

Year	DEPTH											
	2 FEET				3 FEET				6 FEET			
	Date	Max	Date	Min	Date	Max	Date	Min	Date	Max	Date	Min
1889	July 18..	67.3	Jan 28...	30.9	Aug 19...	64.6	Jan 29-31	33.3	Sept 5-10..	60 0	Mar 3......	39.2
1890	July 17 27 28-Aug 7.	66.9	Feb 11...	30.6	Aug 21..	64.6	Jan 29...	33.3	Sept 1-12..	60.0	Feb 18.....	39.4
1891	July 26..	68.7	Feb 14 16-17......	32.1	Aug 16 17 19-20...	65.6	Feb 19, 22 23, 26...	34.0	Sept 17..	63.8	Mar 12-23..	39.0
1892	Aug 17 .	68.7	Jan 24 25	31.4	Aug 18...	65.5	Feb 28...	33.6	Sept 1.....	60.2	Feb 24-26..	39.6
1893	* July 6..	75.3	Jan 22...	32.6	July 24..	67.6	Jan 23-27 Feb 11..	34.8	† July 6.....	67.4	Feb 21,22-25	40.2
1894	‡ June 28..	69.8	Feb 25...	31.5	° June 28..	69.7	Feb 27-28	33.5	‖ June 28....	64.4	Mar 15.....	38.5
1895	Aug 2....	68.0	Jan 16...	27.5	Aug 7-8..	65.9	Jan 18...	32.8	Aug 30 to Sept 19....	61.0	Feb 28 to March 1 .	39.3
1896	Aug 15 17	71.9	Jan 6....	31.6	Aug 16 17	69.5	Jan 8, 17, 18	35.5	Aug 21-25..	62.8	Feb 17-22..	41.0
1897	Aug 12...	§ 76.1	Feb 2.....	32.4	§ Aug 17...	§ 73.6	Feb 2-10.	35.5	§ Aug 16....	§ 75.5	Mar 24 to Apr 2.....	41.0

* Water applied to lawn 69.2 July 31 was probably the highest otherwise.
† " " " " 62.6, Sept 11-13 " " " "
‡ July 31 68.5, unaffected by water.
° Aug 22 66.7, " " "
‖ Sept 2 62.5, " " "
§ Affected by irrigation.
Observations made at 2 and 9 before July 1, 1889.

AN ILLUSTRATION OF THE INFLUENCE OF IRRIGATION ON SOIL TEMPERATURE.

§61. The control which irrigation gives of soil conditions is well known by students of irrigation and is more or less realized by farmers in the arid regions. The extent of this influence is, however, not often recognized, and it is rarely that an illustration as clear as was shown by the soil temperature observations during August, 1897, is to be obtained. In this case our soil thermometers being placed in the grass plat were so situated, that the irrigation of the lawn flooded, to a depth of some inches, the ground where the instruments were placed, and the irrigation was continued long enough to saturate the ground underneath. The temperature at a depth of six feet had been nearly uniform at 62° for a number of weeks before the date of irrigation on August 12th.

§62. With the application of the water it is noticed that the temperature immediately rises, reaching a temperature of 71° almost immediately after. The temperature fell almost immediately after the irrigation, so that during the next three days it had fallen to 64½°. On August 16th the irrigation was repeated, and this time the effect of this added to the effect of the first was to increase the temperature to 75½°. The temperature dropped rapidly to 69°, and then dropped gradually, not again reaching 62° until October. The effect of irrigation on the plat of ground and its vicinity, was felt for more than a month.

§63. The effect on the temperature at two feet and at at three feet in depth was much the same. At the first irrigation the temperature at two feet was increased over that at the lower depths. At the second irrigation the effect on the deep thermometer was almost as great as upon the two foot thermometer.

For the depths less than two feet, the diurnal fluctuation is marked, and as the corresponding curves confuse the diagram, they are omitted. The shallower thermometers also show the cooling effect from evaporation so much that their temperatures fell below the deeper ones.

§64. In view of the influence which temperature has upon the growth of plants, the importance of the fact shown in the diagram is apparent. Evidently the irrigator can increase the temperature of the soil by application of water of proper temperature. It is also evident from corresponding observations at the shallower depths, that the cooling efect on the soil from evaporation may be considerable.

§65. But as the application of water warmer than the

soil will carry heat down into the soil and raise the temperature in spite of the cooling effect of evaporation, so an application of colder water has the opposite effect and chills the soil, both by the direct abstraction of heat and from evaporation.

§ 66. The diagram is here given because of its suggestiveness, and to call attention to the influence of the temperature of the water used. It also suggests a reason why most farmers find it undesirable to irrigate early in the spring and why fall irrigation is sometimes so advantageous irrespective of the need of moisture.

The importance of considerations of this kind, illustrated by the diagram, will be considered more extensively when the observations on irrigation and on soil temperature are published.

OBSERVATIONS SHOWING THE EFFECT OF IRRIGATION ON SOIL-TEMPERATURE

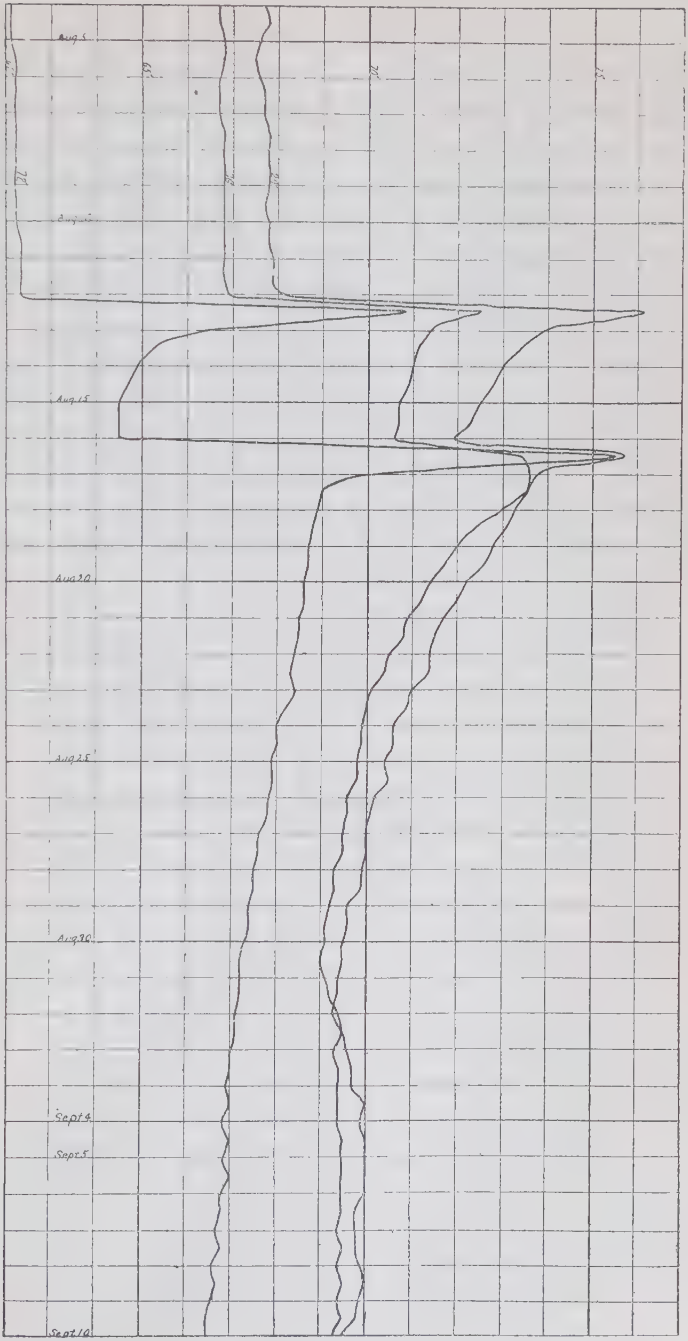


Fig. 17.

EVAPORATION.

§67. Table 10 gives the evaporation from our standard evaporation tank. This is sunk in the soil level with the surface. Observations with the hook gage are made twice per day from April to September, gage reading to one thousandths of a foot. At the same time the temperature of the water surface is observed twice per day at the maximum and minimum temperatures. During September and October the reading is made once daily. During the winter months ice forms and the observation is made at the beginning of each month.

It is found that the evaporation runs from one to two inches per month during the winter. The evaporation during the night is practically as rapid as during the day.

§68. An attempt was made to obtain a formula from the observations of 1889, and with enough success to compute the evaporation in 1890 from May to October with a difference of less than half inch. The formula was as follows: $E = .39\ (T-t)\ (1+.02W)$.

E represents the evaporation in inches in 24 hours.

T is the vapor tension corresponding to the temperature of the surface of the water.

t is the vapor tension corresponding to the temperature of the dew point at that time.

W represents the number of miles of wind in the 24 hours.

Observations have since been made to obtain a more perfect formula, but are not yet reduced.

TABLE 12.

EVAPORATION FROM WATER SURFACE, TANK 3x3x3 FEET, FLUSH WITH GROUND AT FORT COLLINS, COLO.

Latitude 40° 34′; Longitude 105° +; Elevation 4,990 feet.

YEAR	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1887	2.46	3.23	4.60	5.55	5.19	5.75	5.23	4.24	4.12	3.26	1.48	1.60	46.71
1888	......	......	......	......	4.45	†7.70	†7.00	4.06	3.94	2.17	1.35	0.99	......
1889	1.08	1.03	2.75	4.06	3.72	4.34	5.20	5.15	5.19	3.28	0.62	1.42	37.84
1890	0.86	2.36	3.58	3.50	4.32	5.71	5.44	5.76	3.69	2.71	1.32	1.10	40.25
1891	*1.89	1.90	2.23	2.24	5.03	4.97	5.72	4.91	4.12	3.62	1.74	0.75	39.12
1892	2.51	‡2.15	2.78	3.58	3.49	4.20	4.69	5.64	5.11	3.33	1.93	1.13	40.54
1893	P	*1.52	3.79	5.40	5.12	6.12	6.41	4.73	5.04	3.79	1.05	1.38	......
1894	†1.14	†1.15	1.95	4.61	4.66	5.01	5.74	4.88	3.77	3.75	1.64	1.22	39.52
1895	†1.19	†1.19	P	4.91	4.27	4.13	4.57	4.52	4.06	2.24	1.53	1.68	......
1896	2.64	2.25	2.39	4.71	5.91	5.09	5.23	5.80	3.34	2.94	1.62	1.25	43.17
1897	1.80	2.20	P	3.33	4.13	4.26	4.64	4.76	3.97	2.88	1.47	0.94	......
Average	1.73	1.90	3.00	4.19	4.57	5.21	5.44	4.95	4.21	3.09	1.43	1.22	40.94

* Record from part of month.
† From record of two months.
‡ From record from February 17.
P Tank punctured, record lacking.

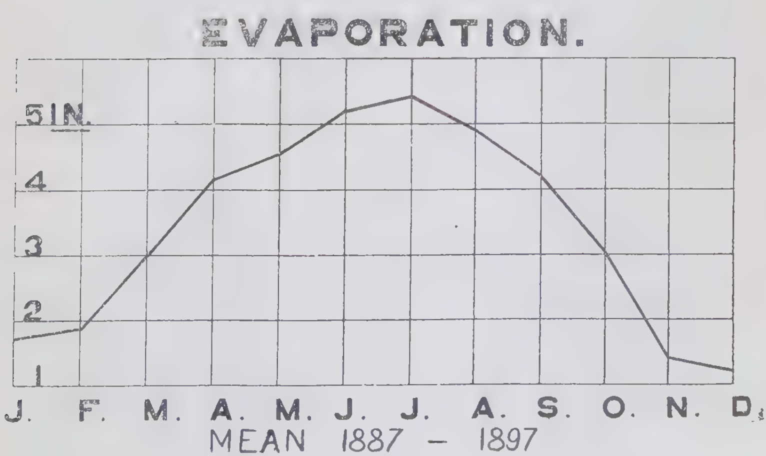


Fig. 18.

TABLE 13.

§69. The wind movement for the year has amounted to nearly 60,000 miles. March and April have been the windiest. By months the record is as follows :

	Direction.	Number of Miles.
Jan.,	N. W.	5058.3
Feb.,	W.	5622.6
March,	W.	7038.7
April,	N. W.	6614.3
May,	N. W.	4968.4
June,	E. W.	4302.5
July,	S. W.	4274.2
Aug.,	N. N. W	3532.4
Sept.,	N. W.	3483.4
Oct.,	N. W.	4723.9
Nov.,	N. W.	5003.3
Dec.,	N. W.	5534.7
Total for year		59356.7
Average	N. W	4946

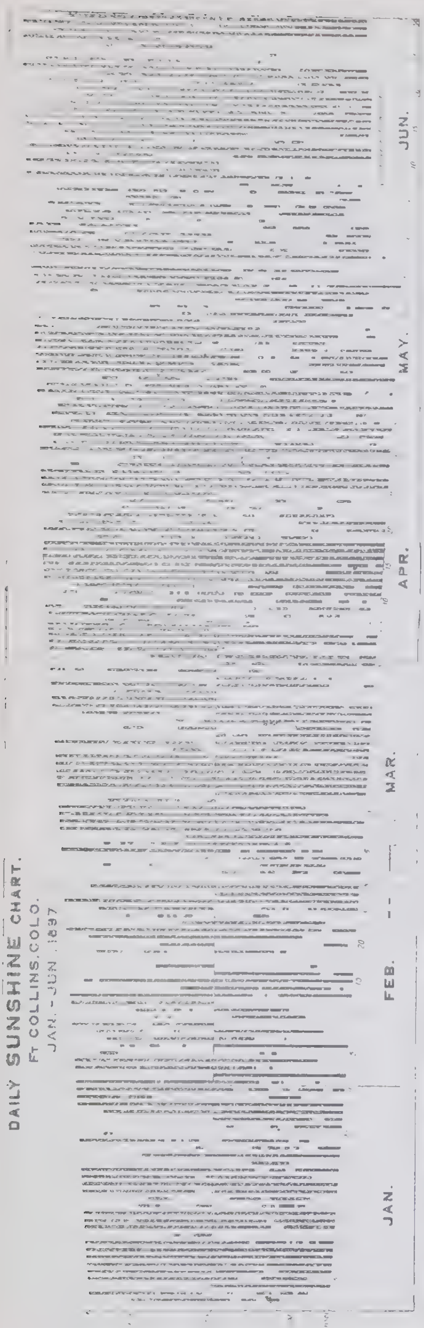
SUNSHINE.

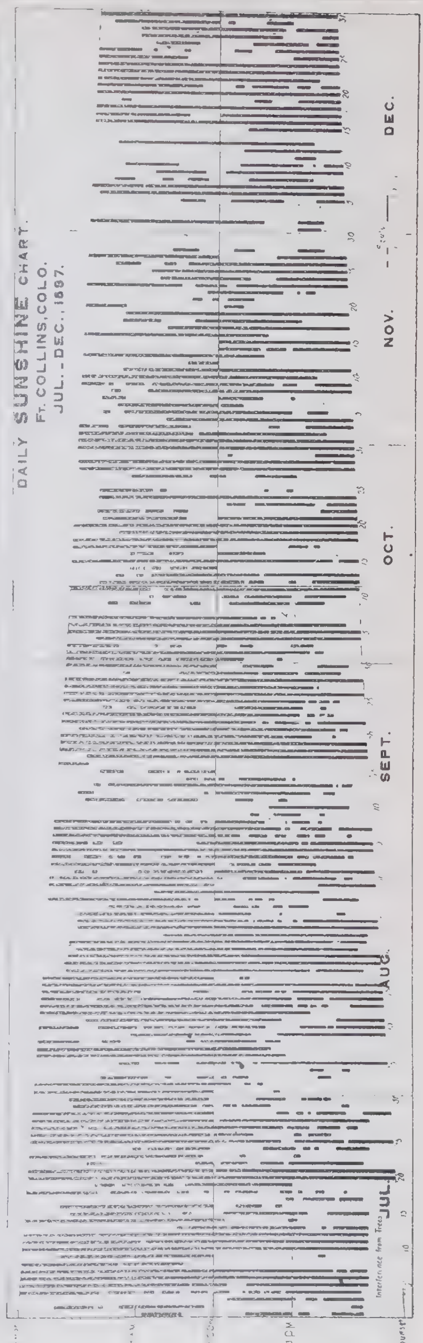
§70. Instead of giving the sunshine throughout the year by tables, an attempt is made in figure 19 to show graphically the amount through the year, showing not only the amount received each day, but the time when it occurs, which would be impossible to show clearly in a table.

A space is given for each day. The occurrence of sunshine is shown by the heavy line and the length of the line shows the duration of the sunshine, which can be determined by comparing with the scale. Cloudiness or the absence of sunshine is shown by the line being blank.

The upper line in the diagram represents the time of sunrise,--when, on a clear day, sunshine should begin,--the lower line, sunset. The distance of these lines from the middle line, representing noon, is proportional to the length of the forenoon and of the afternoon respectively. Allowance has been made for the shortening of the afternoon due to the presence of mountains on the western horizon. The two other lines represent 9 a. m. and 3 p. m., and are placed three hours distant from the middle or noon line. The time is, therefore, counted in apparent or sun time, without allowance for the equation of time.

If, therefore, the sun shines from its rising to its setting,


DAILY SUNSHINE CHART.
Ft COLLINS, COLO.
JAN. - JUN. 1897
JAN.
FEB.
MAR.
APR.
MAY.
JUN.


DAILY SUNSHINE CHART.
Ft COLLINS, COLO.
JUL. - DEC., 1897.
JUL.
AUG.
SEPT.
OCT.
NOV.
DEC.
Interference from Trees
Sunset

the full line extends from the sunrise to the sunset line. If a cloud obscures the sun for a time, this is indicated by a break in the line, and the duration of the obscuration is shown by the length of the break. Hence the broken lines represent intermittent sunshine, or days of floating clouds. The spotted character of the diagram in the same months shows a feature noticeable in our mountain meteorology; fair weather in the forenoons, and of floating cumulus clouds or local thunder storms in the afternoons.

§71. The chart has been made from the photographic record made by means of the Pickering sunshine recorder, already described. As the intensity of the sunlight is not enough to record near sunrise or sunset, some element of judgment is involved both in the table and in the diagram in estimating the period of about half an hour near those times. As the diagram and the measurement were made by different persons, there may be a slight discrepancy in estimating this period in the two cases.

The distribution of the sunshine through the year is noteworthy, and to those interested in Colorado climate, whether as agriculturists or as health seekers, the chart will prove worthy of careful examination.

It will be noticed that there are many days on which the sun shines throughout the whole day; there are very few when it does not shine for a greater or longer time, but there were several days in 1897 when no sunshine is recorded by the sunshine recorder. The groups of sunshiny days are also noticeable in the diagram, their occurrence usually being at the same time as a wave of high barometric pressure.

§72. The important effect of sunshine on the maturation and quality of grains, the coloration of fruits and flowers, and its important influence from a sanitary standpoint, are too well recognized, to need more than a reference here. From the standpoint of Agricultural Meteorology both the amount and the intensity of sunlight are among the most important of the elements to be observed and studied, and while the connection between the sunlight and the growth and development of plants is complicated and surrounded with many difficulties, some of the definite relations are not beyond the possibility of determination. Records of the amount of sunshine since 1888 have been kept by similar methods at a number of stations and later it is hoped to give a more complete discussion of the questions relating to sunshine and its agricultural importance.

TABLE 14.

SUNSHINE 1897, SHOWING NO. OF HOURS AND MINUTES OF SUNSHINE OBSERVED AND THE PER CENT OF THE POSSIBLE.

MONTH	Sunshine to 9 a. m.		9 a. m. to Noon		Noon to 3 p.m		3 p. m. to Sunset		For Month	
	hrs min	Per Cent	hrs min	Per Cent	hrs min	Per Cent	hrs min	Per Cent	Total Hours	Per Cent.
January	26–43	45.8	60–41	65.2	63–03	67.8	23–08	50.0	173–35	60.4
February	26–20	41.4	47–40	56.8	53–49	64.1	22–30	41.1	150–19	52.6
March	41–37	46.0	55–53	60.1	62–48	67.5	43–59	54.1	204–17	57.1
April	61–38	68.5	66–01	61.4	51–09	56.8	50–12	50.7	229–00	59.2
May	81–06	63.1	77–32	83.2	55–25	59.6	49–19	40.7	263–22	60.5
June	76–38	57.7	60–02	66.7	48–17	53.6	51–11	40.5	236–08	53.8
July	83–18	62.8	73–00	78.5	55–57	60.2	66–42	53.2	278–57	62.8
August	69–01	54.2	78–26	84.3	63–35	68.4	52–37	48.4	263–39	64.0
September	51–31	65.8	65–31	72.8	71–49	80.0	44–24	52.0	233–15	64.9
October	42–33	53.3	65–15	70.2	63–09	70.2	36–53	53.0	207–50	63.1
November	19–55	35.3	55–00	61.1	60–11	66.9	24–04	48.5	159–10	56.0
December	19–15	42.3	54–37	57.7	59–18	62 6	25–18	60.8	158–28	57.3
Total Hours	599–35	......	759–38	......	708–30	......	490–17	......	2559–27	......
Average Per Cent	52.0	......	69.4	......	64.7	......	48.9	......	59.6	......

ACKNOWLEDGMENTS.

The planning of the observations, their character, and all questions of the forms of instruments, methods of observation and of reduction, corrections, etc., the head of the section is responsible for. The observations themselves in 1897 have largely been taken by Mr. Trimble and their reduction has been made or verified by him. During June, July and August, during the absence of Mr. Trimble assisting in other investigations, the observations were made principally by Mr. H. F. Alps, now connected with the U. S. Weather Bureau, but the reductions have been made or verified by Mr. Trimble. In September most of the observations were made by Mr. J. D. Stannard. The sunshine records were measured and the monthly sums found by Mr. W. R. Headden, now of the senior class in the Agricultural College. The diagrams representing thevarious observations, in figures 12 to 19 have been made by Mr. J.

C. Mulder, now of the senior class in the Agricultural College, who was employed as draughtsman during the summer.

The figures illustrating the instruments referred to have been obtained from the manufacturers, the names attached showing the source. Those of the French firm of Richard Freres, were copied from their catalogue. Figure 8 is from the firm of W. and L. E. Gurley, of Troy, N. Y. The figure of the statoscope record is due to the courtesy of the Engineering News Pub. Co., N. Y., the figure being made from records taken here.

TABLE OF CONTENTS.

TABLES.

ILLUSTRATIONS.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO 50.

Notes on Plum Culture.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

DECEMBER, 1898.

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FORT COLLINS, COLORADO.

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NOTES ON PLUM CULTURE.

BY CHARLES S. CRANDALL.

Prefatory note on the application of horticultural rules.

There are certain general rules in the practice of horticulture that are capable of wide application. If we say that cherry trees should never be planted on wet or mucky soil, we state a general rule, equally applicable to any section of the country.

There are certain other rules, such as those governing the choice of varieties, selection of stocks, season for and manner of budding or grafting, time of planting and frequency of irrigation, that may be called specific rules. These are of necessity local in character and may be quite restricted in application.

Possibly no state presents greater diversity in local conditions that govern horticultural practice than does Colorado. Not only do wide differences exist between eastern and western sides of the Continental Divide, but either slope may be divided into sections that would warrant considerable differences in practice on many points, and then, each section may have peculiarities that would subdivide it. Even the differences between the two banks of a stream, or the varying soil conditions of two adjoining farms, may present factors that modify successful practice.

If a man moves from one section to another he will naturally attempt to grow the varieties and follow the methods with which he is familiar. He meets failure in many particulars and after a time learns by experience that his new surroundings call for different methods and likely different varieties. It has always been the experience in new countries that the pioneers in horticultural work made mistakes which they found expensive and discouraging, but by persistence they learned to avoid the early errors and finally

achieved success. Later comers can, and should, profit by the experience of these pioneers. The methods they have found successful can be safely followed, no matter how they differ from those successfully practiced elsewhere.

The specific rules to which I here refer are often discussed in public, and frequently the views expressed are very diverse. Two men may discuss a particular practice, each persistent in holding his honestly expressed conviction, derived from personal experience, to be the only correct one. Each knows he is right and no amount of discussion will bring them to the same view. The newcomer seeking information is confused by the opposite views so strenuously contended for. Transactions of societies and the horticultural press bear evidence that such discussions are not infrequent. The writer is of the opinion that in many cases these discussions do more harm than good, or are at least profitless, because they are dropped with the differences unexplained. Inquiry will often bring out differences in the local conditions under which the experiences have been acquired that will fully account for the diverse views expressed.

The idea that I would emphasize and urge upon those who contemplate entering upon horticulture as a business is, that a careful study should be made of all the conditions surrounding the particular place chosen. Sum up the experience of the pioneers, consider the liability to late spring frosts, and early fall frosts, to storms and winds. Examine into the water supply, soil, subsoil, slope, exposure, direction of prevailing winds, and every other feature that may have bearing upon future success. Attention to these factors will enable intelligent action, saving expense and avoiding disappointment.

I am lead to dwell in some detail upon this matter of the application of specific rules because so many requests for advice on the points enumerated are constantly being received. Usually inquiries are unaccompanied by any statement of local conditions or aims in view, and it is difficult, often impossible, to give the desired information except in the most general terms, and this is unsatisfactory both to the writer and to the seeker after information.

DERIVATION AND DISTRIBUTION OF OUR PLUMS.

The genus Prunus as now constituted embraces those species from which have been developed all our stone fruits, Almonds, Peaches, Nectarines, Apricots, Plums and Cher-

ries. Its representatives are widely distributed over the earth and the number of species as given by different authors varies greatly. Bentham and Hooker in their Genera Plantarum place the number at about eighty. A later work, the Index Kewensis, recognizes 121 species, and records 290 names as synonyms. The 121 species here considered valid are distributed as follows:

Eastern hemisphere 87 species, 15 of which are credited to Japan and 12 to China. Western hemisphere 32 species, 21 of which belong to the United States and the region north. Seven are credited to Mexico and four to South America and the West Indies. Two species are recorded as of unknown origin.

Our American manuals record species of the genus as follows:

Botany of California (1876), 6 species.

Chapman's Flora of the Southern States (1883), 7 species.

Coulter's Manual of the Rocky Mountain Region (1885), 5 species, 1 variety.

Gray's Manual, 6th Ed. (1890), 10 species, 1 introduced variety.

Coulter's Flora of Texas (1891), 8 species.

The Britton and Brown Flora (1897), 16 native, 4 introduced species, 2 native and 1 introduced varieties.

Taken together these floras recognize 27 native and 4 introduced species, and 3 native and one introduced varieties.

Of the native representatives of the genus, 16 species and 1 variety are true plums, or of such close affinity as to readily class with them, while 11 species and two varieties are cherries or belong with the cherry group. Nearly all the species enumerated in the manuals are, or have been at some time, introduced into gardens and cultivated, either for their fruits or as ornamentals, but the varieties now catalogued by nurserymen and grown in orchard, represent but few species. Of the native cherries only the shrubby sand-cherries (*Prunus pumila*, *P. Besseyi*, and *P. cuneata*) are grown for fruit. The Wild Red Cherry (*P. Pennsylvanica*) is occasionally used as a stock upon which the common sour cherries, of European origin, are grafted; it has also been used to a limited extent as a stock for some of the plums.

Of the native plum group, three species (*P. Americana*, *P. hortulana* with its variety *Mineri*, and *P. angustifolia*) have furnished nearly all of the cultivated varieties. The Beach plum (*P. maritima*) is the parent of but one variety of

doubtful value. The Mariana so largely used for stocks, and the De Caradeuc are closely related, but of uncertain origin. A few varieties are probably hybrids, although the manner in which most of them originated is more a matter of speculation than of definite knowledge. There are still other varieties that cannot even be classed as hybrids and whose ancestry is likely to remain undetermined. Professor Bailey of Cornell, who has given the whole plum group careful study, arranges the native varieties into groups as follows:*

The American Group—*Prunus Americana.*

The Wild Goose Group—*Prunus hortulana.*

The Miner Group—*Prunus hortulana* var. *Mineri.*

The Chicasaw Group—*Prunus angustifolia.*

The Mariana Group—Of uncertain origin. De Caradeuc assigned to *Prunus cerasifera*, and Mariana thought to be a hybrid.

The Beach Plum—*Prunus maritima.*

The Wild Plum of the Pacific Coast—*Prunus subcordata.*

Hybrids, unclassified varieties—Of uncertain origin.

Our foreign introductions belong to two groups:

The European Plums, such as Lombard, Green Gage, and the numerous prunes—*Prunus domestica.*

The Japanese Plums—*Prunus triflora.*

While the European plums can be grown in some sections, the tender nature of the fruit buds makes them uncertain on the eastern slope, except in favored localities, and dependence must be placed mainly upon the Americana varieties. In the fruit districts of the western slope the Wild Goose is eminently successful and stands at the head of the list of profitable varieties, but it is probably too tender for the eastern slope, certainly for the northern and central districts.

In general throughout the West the native plums are proving profitable. Even in districts where the domestica varieties are successfully grown, the native red plums sell in competition with them, and at remunerative prices. While it may be admitted that most native varieties are inferior in size and flavor to those of the domestica class it, should be remembered that the extended introduction of the natives is comparatively recent, that the improvement in them has been rapid, and that they offer wonderful possibilities in the direction of future development. All the

* See bulletin No. 38, Cornell Experiment Station.

better varieties are very productive. Some show a strong tendency to excessive production, a habit which if allowed to go unchecked, not only gives inferior fruit, but tends to shorten the life of the tree. With such varieties systematic thinning must be practiced in order to insure regular crops, and fruit of the largest size and best flavor. Then, having produced good fruit, if the grower will exercise the same care in handling that is given other fruits, and will place them on the market in the same attractive packages, the demand which already exists will be greatly stimulated.

PROPAGATION OF THE PLUM.

Most varieties of plums have come to us as seedlings selected and retained because of their good qualities; they show development or variation from wild types in varying degree, but with all, the departure is such that we can not reproduce them through the seed, and in order to maintain them we are forced to adopt other means.

All varieties are perpetuated by either budding or grafting, usually on plum stocks. The kinds available as stocks are various and exhibit as great differences as appear between the varieties to be propagated. No one stock can be regarded as perfectly satisfactory for general use with all varieties, and it follows that care and thought must be exercised in making choice of what shall be used.

The character of the soil, whether light or sandy, or verging on the other extreme of heavy clay, and the general features of the climate will largely govern this choice, but consideration must also be given to the characteristics of the varieties to be propagated.

The desirable varieties have parentage in widely different species, each of which has characteristics peculiarly its own. The derivative varieties follow more or less closely after the parent species, inheriting habits, likes and dislikes, which must be regarded if we achieve success in their management. Even among derivatives of the same species we may find varieties sufficiently different to call for the use of different stocks and different methods of treatment. This would be looked for among the varieties that have been under cultivation for the longest periods, and is due to the fact that the variation and development from the original type has not been along parallel lines. Differences in climate, in food supply, and in general environment have led to diver-

gence resulting in races which possess distinctive and well-marked characters.

Some knowledge, therefore, of the history and derivation of varieties is essential to the propagator in order that he may make intelligent selection of the stocks upon which to work his profitable varieties. Successful propagators, well versed in the history of varieties, and in the principles of culture will, however, often differ in their estimate of available stocks, just as they will differ on methods of practice. Strong growing varieties are not suited to very slow growing stocks because they over-top them and the trees are short lived. On the other hand success does not follow the attempt to force a slow-growing variety by working it upon a rank-growing stock. The nearer the variety to be grafted corresponds with the stock to be used in general habit and vigor of growth, the better will be the prospects for health and longevity in the tree.

Figures 1 and 2, Plate I, illustrate an overgrowing of the stock that is not uncommon. Figure 1 is a Yellow Sweet, (*Prunus Americana*,) planted in 1894. The enlargement just above the union is marked, and it is increasing each year. Figure 2 is a Wolf (*Prunus Americana*) tree of uncertain age, probably 14 or 15 years old, in which the enlargement is still more marked. We have no information as to the stocks used in either of these cases, but the fact that there is not perfect affinity between the varieties and their stocks is apparent.

For the European plums such as Lombard, Green Gage, and Bradshaw probably no stock is better than seedlings of some variety of the species from which these varieties came —*Prunus domestica*. These have been in common use for many years, but in recent years have been in some degree superseded by Myrobalan stocks (seedlings of *Prunus cerasifera*, a species of European origin). Myrobalan stocks are in common use in European countries and have rapidly grown in favor with our nurserymen, not because better trees can be grown upon them, but because it is easier to secure good Myrobalan than good domestica stocks. Seeds of domestica varieties that will produce an even stand of stocks is difficult to obtain, and the Myrobalan, which is easier to grow and less liable to injury from parasitic fungi, offers an acceptable substitute. Some nurserymen import the seeds and grow their own stocks, others find it more profitable to import the seedlings. They are usually received during the winter, planted in nursery rows in spring, and budded in July and August. In the south the stocks in

common use are the Marianna plum and the peach, and very diverse opinions as to their relative merits have been expressed. Probably the differences arise from varying local conditions, for the testimony at hand indicates that on the light and dry soils the peach stock does best, while the Myrobalan is better suited to the heavier and more moist soils. Even at the north the peach meets with some favor as a stock for plums on light soils, but it is too tender for districts where severe winters are common. For the native varieties, Wolf, Weaver, De Soto and other derivatives of *Prunus Americana*, the natural inference that Americana stocks would be best seems to be borne out by experience, but the degree of success may depend in a measure upon the seed used. The species is extremely variable in general habit and rapidity of growth as well as in the fruit produced. Seeds from which to grow stocks should be chosen from vigorous free-growing trees only. The progeny of such trees will most nearly accord with the varieties to be propagated and better insure the future of the tree. Seeds are obtained in the fall, separated from the pulp, mixed with sand and kept in a cool, moist place, during the winter. If they can be frozen and thawed several times, so much the better, for they will then more readily crack under the pressure of the swelling embryo.

In spring they are sown in seed beds of deeply stirred rich soil. In the fall the seedlings are lifted, sorted and packed away in sand in a cool pit or cellar. The following spring they may be planted in nursery rows to be budded in July and August. The commencement of the budding season is determined by the maturity of the scion buds to be used; they are buds of the current year's production and must be well matured. Budding may be continued as long as the bark will "slip," and this as well as the maturation of the scion buds will be largely influenced by weather conditions. The length of the budding season may, therefore, vary greatly in different years. Usually the season with plums is shorter than with peaches or apples. About ten days after insertion the buds should be examined and the bands loosened if necessary. Where buds have failed to unite, the stocks may be rebudded and this may be repeated as often as the length of the season will allow. Late in the fall stocks on which buds have failed should be taken up and stored for grafting in late winter or early spring. When growth starts in the spring the budded stocks must receive prompt attention. The stock must be "headed down," that is, cut off above the bud, and here practice varies somewhat.

Some growers prefer to cut from four to six inches above the bud, while others would at once cut as close to the bud as it is safe. The idea in cutting high is to leave a stub which may serve as a support to which the shoot from the bud may be tied, the stub being removed at the close of the first season's growth. All shoots below as well as above the scion bud must be removed, otherwise they will starve the bud by diverting the sap to their own development. Further production of these shoots from the stock will occur, and they must be frequently checked in order to secure the best growth of the scion.

By far the greater number of plum trees grown commercially are produced by this process of budding. It is the easiest and best way when trees are grown in quantity, but as good trees can be produced by grafting, and often it is more convenient to graft than to bud. Here at the station we have used both methods and have found grafting rather more uniformly successful than budding. During the budding season the weather is hot and dry, and frequently no water is availabie for irrigating; many buds dry out and fail to take, so that under conditions similar to ours the writer believes the method of propagating by grafting will give the best satisfaction, and particularly to the fruit grower who propagates in a small way for his own use. I am aware that the idea is current that stone fruits, and particularly plums, are difficult to graft. It is true that certain precautions must be observed that need receive little attention when grafting the apple, but these simple precautions taken, the work is no more difficult and success is as certain as with the apple. Of course the mechanical work of putting scion and stock together must be well done, but outside of this there are three points upon which success mainly depends:

1st—The perfectly dormant condition of both stock and scion at the time the operation is performed.

2nd—The protection of the union by coating with wax.

3rd—Proper care of the plants between grafting and setting in nursery.

The work is usually performed during March or April, and may be continued so long as the dormant condition can be maintained. Plums, however, start growth under slight stimulus, and a few warm days will end the work, even when all ordinary precautions have been taken. We have frequently filled the passage-way in our outside storage-pit with snow and ice as a means of keeping the temperature down, and have thus gained a few days. It is best to com-

mence early enough so that the finish need not be hurried by the weather conditions.

Scions must not only be dormant, but must be otherwise in good condition, neither wilted from drying, nor water soaked from being kept too wet. Sometimes it is convenient to take them from the trees as wanted; more frequently they will be cut late in the fall, or come from a distance, and the question of how to keep them will present itself.

They may be kept in an outside cellar or pit, packed in dry leaves, or in moss that is but slightly damp. The aim should be simply to provide conditions that will prevent the loss of moisture, without affording opportunity for the absorption of an excess.

The particular method of grafting to be used is much a matter of taste. Several are available, among which the four following are named in the order of the writers preference: Veneer, Side, Whip and Cleft.

The side graft is probably in more general use than any of the others, but after several years experience with all of them we are inclined to favor the veneer method as giving the most perfect union.

It is not our purpose to here discuss the principles of grafting, but may remark that in all grafting no union takes place between cut surfaces of the wood. It is only through the adjustment of the cambium of the scion to that of the stock that union is secured, and here, it is not a union between cells existing at the time the grafting is done, but through new cells formed in extension of the cambium, which is the only channel of communication between leaves and roots. This being true it seems reasonable that the less the area of cut wood surfaces the better. The minimum of cut wood is secured by the veneer graft, which only exposes the wood in the oblique transverse cuts at the apex of the stock and the base of the scion. The one valid objection that may be urged against the veneer graft is that the scion is easily displaced. It is easily displaced if carelessly tied, but with reasonable care no trouble need be feared.

Whatever the method used the union should be thoroughly covered with some protective wax. A liquid wax to be applied with a brush is most convenient, and of several preparations one known as "Alcoholic Plastic" answers the purpose admirably. It is made as follows: One pound of Resin, and one ounce of tallow melted together; remove from the fire, and after cooling slightly, but while still liquid, add eight fluid ounces of alcohol and stir thoroughly. This

preparation must be kept in a corked bottle or other closed vessel to prevent the evaporation of the alcohol.

After waxing, the grafted stocks should be returned to the cellar and kept at as low a temperature as possible without freezing until the time arrives for setting in nursery. The roots may be placed in damp sand, but the scions should be subjected to such a degree of moisture only, as will prevent drying out. The practice as here outlined is successfully followed in our station work. In all grafting of plums the scion should be set low on the crown so that when planted in the nursery the union may be placed well below the surface.

The plum is seldom worked above the ground, and there seems to be nothing in the practice to commend it for practical purposes. If it is attempted it should only be with varieties of close affinity, and trees of equal vigor. Scions from a slow-growing tree can not keep pace with the branches of a strong-grower, and if the strong scion is worked on the slower stock it soon out-grows it and the wind breaks it off. A scion of Indiana Red worked on a wild Americana stock three feet above the ground produced a straight whip five feet and four inches long; three feet above the union the new growth had the same diameter as the stock at the ground. It yielded to a moderate wind.

Sometimes when new varieties are procured for trial, a few scions are worked on old trees of some Americana variety with a view to obtaining fruit quickly. Thus trees of Ogon planted in 1894, have not yet fruited because the tops have killed back every year, but scions from the same trees, taken at the time of planting and worked on Prunus Americana have given us fruit for four seasons. Several other varieties treated in the same manner at the same time, have fruited, but all, or nearly all are now dead.

PRUNING.

Plums are pruned for the purpose of forming and maintaining a symmetrical, well-balanced top. Five or six branches, equally distributed about the stem, and having some vertical separation are selected to serve as a framework of the top. All others are removed and the leader is shortened. The branches retained should be cut back to some extent, but this, as well as the shortening of the leader must be determined for each tree, being dependent upon the root system and the apparent vigor. In shortening the branches

and leader, the cuts should be made with reference to selected buds so placed that the future extension may be in the right direction. During the summer, rub off shoots that start where they are not wanted, and pinch the tips of rampant branches. The second spring, before growth starts, the shoots produced the previous year should be shortened to encourage the production of secondary, interior branches, and the third year this is repeated. From now on no pruning is needed except to remove branches starting from wrong places, and to control the too vigorous branches. This is best done by summer pinching, and in general it may be said that the less the knife is used on plum trees, the better it is for the trees. Most varieties require very little pruning after the head is once formed.

SOILS.

Plums will adapt themselves to almost any soil that would be chosen for apples or pears. Domestica varieties are perhaps best on heavy clay, and choice may be more restricted with them than with most other sorts. The native varieties are suited to a wide range of soils, but no tree will do well on wet mucky soils, and as the plum is a rank feeder and a heavy bearer, the soil must be of good fertility.

Colorado soils are in general well adapted for the plum, but even on the best, good cultivation and the systematic application of fertilizers is to be recommended.

IRRIGATION,

Frequency in the application of water is so entirely dependent upon the character of the soil that no rule can be made to govern it. How best to irrigate must be learned by experience for each orchard. In a general way it may be said that young trees require more water the first season than is necessary in succeeding years. Trees that are bearing, however, should receive almost, if not quite as much, as young trees; it is necessary for the best development of the fruit.

The soil of our station orchard is quite compact; water does not spread quickly, and each irrigation is prolonged for a greater time than would be necessary on more porous soils. When water is available we aim to apply it once in

ten days for young trees; somewhat less frequently for those older.

The effects of drouth during July and August are frequently seen in small inferior fruit. Reasonable care in the application of water during this period will well repay the trouble in the increased quantity and better quality of fruit. It is, however, possible to apply an excess that may work as great injury as the most severe drouth. It is only by studying the appearance of the trees, and the condition of the soil that we can arrive at a correct adjustment of the quantity to be applied, and the time to apply it.

It is our practice here to withhold water after the first of September in order to check growth and allow the wood to ripen. If growing conditions are maintained through the fall the young and succulent wood, of even the hardiest varieties, is in danger of being killed by low winter temperatures, but if well ripened it survives the extremes without injury. Twice within the last six years we have had open winters that proved more productive of injury to trees than those of continuous cold. There were long periods of warm weather, with no frost in the ground, and no precipitation to supply the continuous evaporation. The soil became very dry and the trees suffered in consequence. To guard as much as possible against such injury it is the practice to give a late irrigation, usually in November. If the ground can be well saturated at this time it is of advantage to the orchard whether the months following be cold or warm; if warm, the soil will not so soon become dry, and danger from this source is lessened; if cold and the soil be continuously frozen, the moisture is retained and the conditions for spring growth improved.

The system practiced is to furrow for each irrigation, using a one-horse plow and turning from the trees on both sides of the row. Water is run in the furrows for from 12 to 36 hours according to the supply available and the condition of the soil. As soon as practicable after irrigating, a harrow is used to close the furrow and smooth the surface. The aim is to keep a constant mulch of loose soil on the surface so as to check evaporation as far as possible. The method of applying water is illustrated by plate 2.

PLANTING DISTANCE.

Practice and opinion on the matter of distance between trees in orchard planting is very diverse. The general

tendency is toward too close planting and sometimes this is carried to extremes. I have seen several plum orchards planted 10x10 feet that even now when only five years old have much the appearance of thickets. Cultivation is impossible, the fruit is small and difficult to get at, insects find a safe harbor, and the whole arrangement is unsatisfactory and unprofitable. The condition grows worse with each year. In most cases the suggested remedy, removing alternate trees will not be followed until too late, if at all, and within a very few years the whole must of necessity be destroyed and the labor of planting lost.

The most common practice is to plant 15x15 feet, but this is too close for fully developed trees of spreading habit. A better plan is to plant 15x20 feet, or to adopt the accepted California practice and allow 20x20 feet. There seems to be a d cided preference for low-headed trees on the ground that they are less liable to injury from winds, and that less trunk is exposed to the action of the sun. With low-headed trees the disadvantages of close planting are more quickly apparent. The best formed trees in the station orchard are those headed at from 30 to 36 inches from the ground, and this is the distance we prefer.

Young trees are frequently injured by what are known as "frost cracks," a longitudinal splitting of bark and wood on the south side of the trunk, occurring in late winter or early spring and attributable to the extreme daily range of temperature which often occurs at this season. To guard against this injury the trunks should be protected in some way. Various devices have been used, but we have found wrapping with burlap the most effective and least expensive. Burlap that had been used for baling was purchased at dry goods stores for two cents per pound and cut into four inch strips, three and four feet long; one pound giving as an average 9 strips. These are wound spirally on the trunks, being held at the top by a lap, and by tying with cord at the bottom. One man can cover from 50 to 60 trees per hour with the material prepared and ready at hand. The covering is applied in November and removed in April or May. The same bands will serve for two or three seasons. The whole cost is less than one cent per tree and well repays the trouble.

ARRANGEMENT OF VARIETIES.

The Wild Goose plum has long been regarded as infertile when isolated and the same complaint has occasionally

been made regarding other varieties, but the experiments carried on by Professor Waugh of Vermont, in 1896 and 1897, indicate that the actual extent of self-sterility among varieties of plums, has by no means been appreciated or even suspected. His tabulation shows that of 6,428 blossoms covered, on 56 varieties, representing all classes of plums, only five produced fruits, and from the experiments he draws the conclusion that "For all practical purposes, all classes and varieties of native plums may be regarded as absolutely self-sterile." It is possible that these results might vary with different seasons and in different localities, but making due allowance for possible variations, the results are startling enough to warrant the attention of plum growers everywhere. The cause of this sterility appears to lie largely in the inefficiency of the pollen of the flowers of a plant upon the stigmas of the flowers of the same plant. It lies in a condition known to exist among many wild as well as cultivated plants. One of nature's provisions for securing cross-fertilization, and the plants come under the recognized Knight's Law that "Nature intended that a sexual intercourse should take place between neighboring plants of the same species."

Self-sterility may also be due in some degree to imperfect pistils, the cause for which must be sought in some physiological weakness of the tree, such as might be brought about by the work of insects or disease, or from a feeble condition following the production of a phenomenally heavy crop of fruit. Or it may be due to unfavorable weather conditions prevailing at blooming time.

Recognizing, then, the existence of self-sterility among plums, the aim should be to so associate the varieties that one may supply pollen for the other. No data is at hand to warrant any definite statement as to what varieties are especially adapted to the fertilization of certain other varieties, but it is perfectly plain that to be of use to each other the varieties must bloom at the same time.

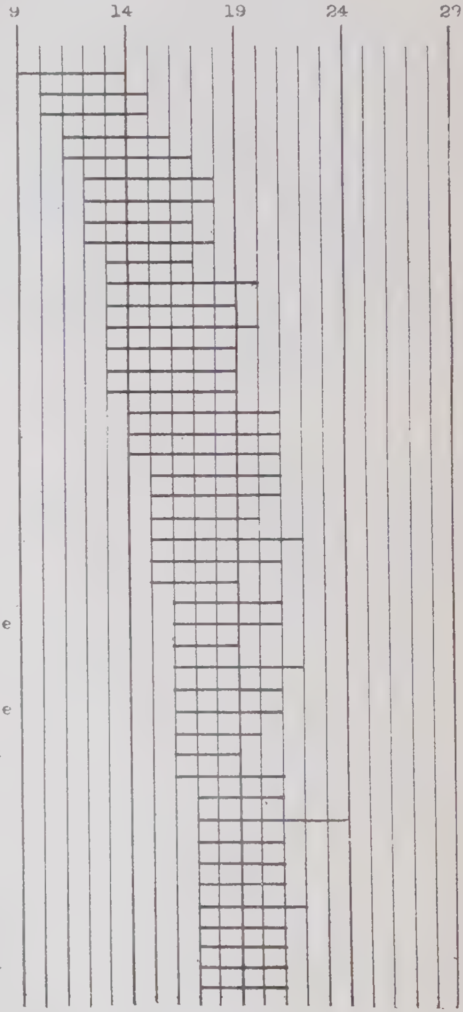
The varieties now available from which to choose show a rather wide range in blooming period; some bloom together, some finish before others begin and some overlap. All are much influenced by the weather at the time, and this may vary greatly in different years, not only in the appearance of the first flowers, but in the length of the blooming period. While irregularities may occur from one season to another, it is probable that the relative periods of the different varieties will remain much the same. For the convenience of those who may be interested, and also as a stim-

ulus to further observations, we here reproduce a graphic tabulation of blossoming periods as given by Mr. J. W. Kerr of Denton, Maryland, in his trade catalogue. The same table is also given by Professor Waugh in the tenth report of the Vermont station. The latitude of Denton is very nearly that of Colorado Springs, but differences in altitude and climate make a considerable difference in the season of growth. The varieties are arranged in the table in the order of blossoming and it serves to show those blooming together as well as the earliest and latest bloomers. It will be observed that the classes to which the varieties are referred embrace three not given in our list; Nigra, Wayland, and Watsoni. The first is separated from *Prunus Americana* and recognizes in the northeastern plums the variety nigra of that species. The Wayland group is separated from the Miner group, with which it has close affinities. The Watsoni group are varieties of *Prunus Watsoni*, a sand plum ranging from Nebraska to Arkansas, and in the cultivated forms closely resembling the Chicasaw varieties with which they are usually classed.

PLUM BLOSSOM CHART.

Showing average plum blossoming seasons in the latitude of Denton, Md.

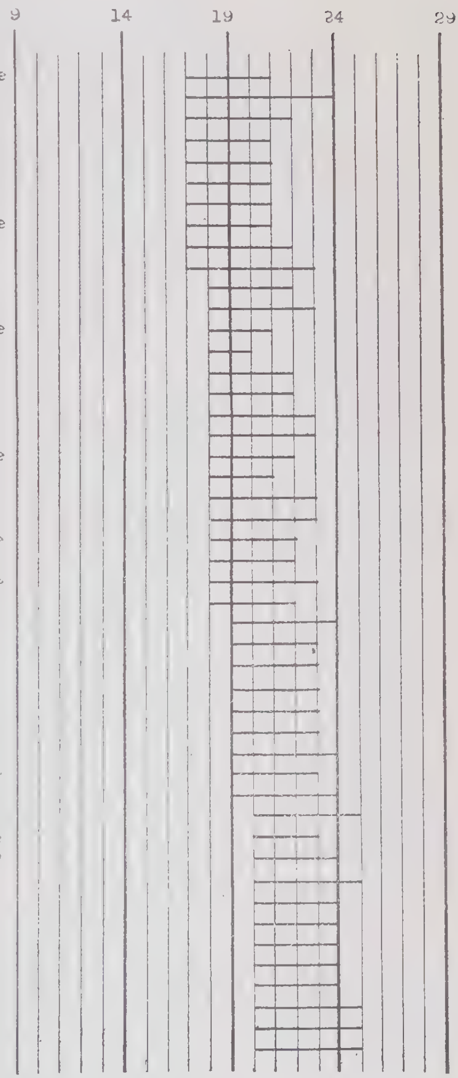
From J.W.Kerr's catalogue. Fall of 1897.



Variety	Class
Burbank	Japanese
Abundance	do
Satsuma	do
DeCaradeuc	Hybrid
Georgeson	Japanese
Engre	do
Marianna	Hybrid
Ogoh	Japanese
Chase	do
Brill	Hybrid?
Chabot	Japanese
Kelsey	do
Ogeechee	Chicasaw
Shiro Sumomo	Japanese
Strawberry	Watsoni
Uchi Beni	Japanese
Maru	do
Wazata	Nigra
Yosebe	Japanese
Caddo Chief	Chicasaw
Early Red	do
Emerson	do
Itaska	Nigra
Kerr	Japanese
Munson	Chicasaw
Beaty	do
Clark	Wild Goose
Clifford	do
Colletta	Chicasaw
Deep Creek	Americana
Drouth King	Wild Goose
El Paso	Chicasaw
Hattie	Myrobalan
Yellow Sweet	Americana
Arkansas Lombard	Chicasaw
Cheney	Nigra
De Soto	Americana
Harrison	do
Heaton	do
Hiawatha	do
Hogg's No.2	Hybrid
Hughes	Chicasaw
Jefferson	Domestica
Lombard	do

Plum Blossom Chart. continued.

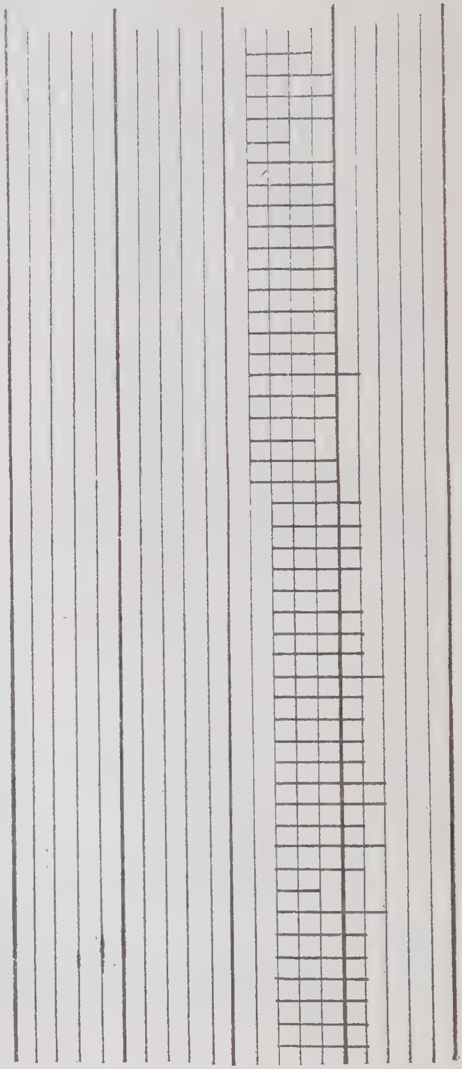
Variety	Class
Milton	Wild Goose
Newman	Chicasaw
Ocheeda	Americana
Richland	Domestica
Rollingstone	Americana
Spaulding	Domestica
Wilder	Miner
Wild Goose	Wild Goose
Willard	Japanese
Yellow Panhandle	Watsoni
African	Chicasaw
Cherokee	Americana
Freeman's Favorite	Wild Goode
Gaylord	Americana
Hilltop	do
Louisa	do
Miner	Miner
Minnetonka	Americana
Ohio Prolific	Wild Goose
Osage	do
Smiley	do
Speer	Americana
Texas Belle	Wild Goose
Van Buren	Americana
Whitaker	Wild Goose
Yellow Transparent	Chicasaw
Comfort	Americana
Cottrell	do
Cumberland	Wayland
Kickapoo	Americana
Lone Star	Chicasaw
Lord's Seedling	Americana
Rockford	do
Roulette	Wild Goose
Schley	do
Champion	Americana
Chas. Downing	Wild Goose
Clara	Americana?
Cluck	Chicasaw
Crescent City	Miner
Columbia	Wayland
Dr. Tyler's Sugar Drop	Domestica
Gordon	Americana
Hammer	do
Hawkeye	do
Idall	Miner
Indian Chief	Wild Goose



Plum blossom chart. continued.

April 9 14 19 24 28

Variety	Class
Indiana Red	Miner
Jewell	Wild Goose
Kampeska	Americana
Kopp	do
LeDuc	do
Maquoketa	Miner
Muncy	Americana
Nelly	do
North Carolina	do
No.0.(Kerr)	do
No.6.(Kerr)	do
No.20.(Kerr)	do
Old Gold	do
Parsons	Miner
Pottawattomie	Chicasaw
Prairie Flower	Miner
Purple Yosemite	Americana
Sophie	Wild Goose
Sucker State	Wayland
Weaver	Americana
Wooten	Wild Goose
California	Americana
Coe's Golden Drop	Domestica
Colorado Queen	Americana
Dakota	do
Forest Rose	Miner
German Prune	Domestica
Hanson	Americana
Honey	do
Iris	Miner
Jones'Late	Americana
Knudson's Peach	do
Macedonia	Wild Goose
Mankato	Americana
Maryland	Hybrid
Missouri Apricot	Wayland
Moore's Arctic	Domestica
Moreman	Wayland
Noyes	Miner
Piram	Chicasaw
Poole's Pride	Wild Goose
Reine Claude	Domestica
Gen.Hand	do
Shropshire Damson	do
Stoddard	Americana
Surprise	Wild Goose
Williams	Nigra



Plum blossom chart. continued.

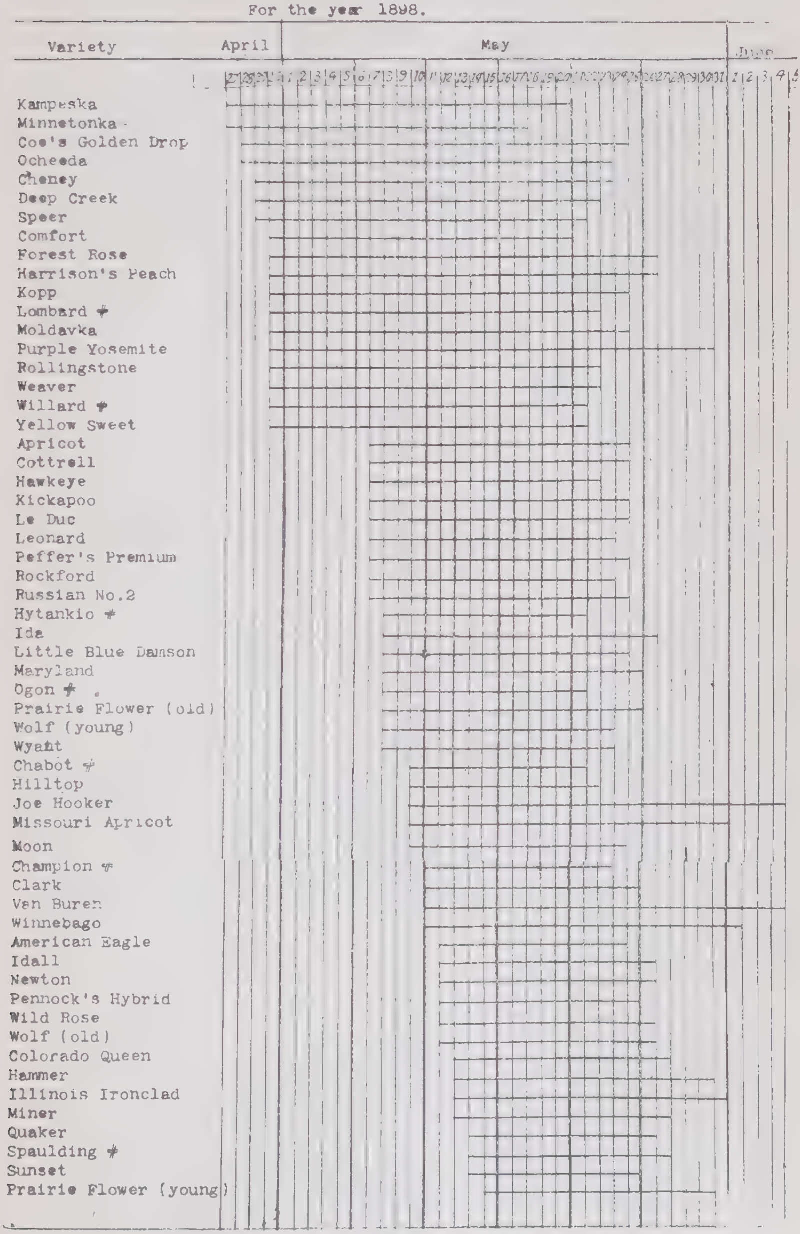
Variety	Class
Williams' No.17	Americana
Wolf	do
Forest Garden	do
Red Panhandle	Watsoni
Smith	Americana
Utah Hybrid	Hybrid
Wayland	Wayland
World-beater	do
Wyant	Americana
American Eagle	do
Garfield	Wayland
Illinois ironclad	Americana
Irene	do
Kanawha	Wayland
Leptune	do
Marion	Americana
Blackhawk	do
Rachel	Miner
Reed	Wayland
Choptank	Wild Goose
Esther	Miner
Galena	Americana
Golden Beauty	Wayland
Heideman's 38	Americana
Heideman's Black	Besseyi
Heideman's Red	do
Heideman's Yell	do
Newton Egg	Americana
Pendent	Wild Goose
Reche	Americana
William's No.0	do
Winnebago	do
Wood	do
Prunus maritima	Maritima
Holt	Americana
Joe Hooker	do
Peffer's Premium	do
Smith's Red	do

The following table arranged on the same plan as the preceeding shows the blossoming period of 56 varieties as compiled from observations in the station orchard last spring. Five of the varieties are represented by old trees of uncertain age, and of whose early history we have no record. They are probably from 12 to 15 years old.

The representatives of five others are young trees planted in 1897 and blooming for the first time. The remainder were planted in 1894. The flowering period of Joe Hooker was probably delayed, and later prolonged by the trees having been killed back somewhat during the preceeding winter. The flowering period is here computed from the time the first flowers opened until the petals had in great part fallen.

Flowering Period of Plums as Recorded in the Station Orchard

For the year 1898.



The two striking differences between the Maryland and Colorado tables are in the commencement of blooming, and in the length of the periods. Variations in climate would lead us to expect differences in the commencement of blooming. This difference here appears as 17 days, and it is probable that variations in seasons might either increase or diminish this. The variation in length of period is extreme. The shortest period recorded in the Maryland table is two days. Our shortest is 12 days. While the longest periods are 7 days in Maryland, and 31 days in Colorado. The great length of the periods observed here may in part be accounted for by the weather conditions prevailing at the time. It will be observed that 11 varieties began blooming on April 30, and that 9 varieties began on May 7, none opening in the interval. This is directly attributable to a storm which prevailed between these dates.

Rain began falling on April 30. On the night of May 2 wet snow accumulated to the depth of 3 inches. This covered the trees and clung to the branches for several days. It was continuously cloudy to the evening of May 5, and while it did not freeze during this period the temperature was sufficiently low to effectually check all vegetation. On examination after the storm it was found that considerable injury had been done. The *Americana* varieties that began opening the flowers before the storm, had most of the pistils in the open, and nearly open flowers killed. Kampeska showed less injury than any other variety of the class. On Minnetonka, Speer, Ocheeda and some others, it was difficult to find an uninjured pistil in open flowers or much advanced buds; most of them were black and shriveled. Coe's Golden Drop among *domestica* varieties had the pistils killed in all open flowers, and also in all advanced buds. Russian No. 2, although having no open flowers, had started the buds to some extent and nearly all were killed. Varieties that were at the time quite dormant suffered no apparent injury.

The storm had the direct effect of delaying the appearance of bloom on most varieties for at least seven days. Whether it effected the blooming period or not is matter of conjecture, but it seems probable that the long period of low temperature may have influenced the vitality of the buds in such way as to prolong the blooming season. The tables are suggestive, and the questions which arise from studying them can only be answered from the data of a number of seasons. Similar tables representing the different districts of the state, and covering other orchard fruits would be

helpful to the planter, and would become more valuable as the number of years over which observations extend, increased.

TO WHAT DEGREE ARE PLUMS SELF-FERTILE.

The following tests to determine self-fertility were undertaken last spring, the work being in charge of my assistant, Mr. J. H. Cowan, who was assisted by one of our students. The preliminary work of covering the flowers was performed on April 30th, with the exception that the flower clusters on one variety, Missouri Apricot, were covered May 7. Grocer's paper bags were used and securely tied. Such flowers as were open, or partially open, were removed before covering, and are not counted. Approximately one half of the clusters were hand-pollinated, the other half being left to themselves. The hand-pollinated set embraced 43 clusters, containing 629 flowers and represented 40 varieties. The stigmas of all flowers were dusted with pollen, either from the same flower, or from other flowers of the same cluster. This work was performed on the dates as tabulated, May 14 18 inclusive. The pistils were at this time in good condition, the stigmas appreciably viscid. The pollen was also in good condition, and the stigmas were copiously covered.

The examination June 6 showed 113 apparently well formed fruits, and 105 imperfect fruits, those that showed some development of the ovary, but did not appear to be well fertilized. In other words it appeared on June 6 that 17.94 per cent. of the flowers had produced good fruits, and 16.69 per cent. had set imperfect fruits. At the final examination June 23 there remained 6 fruits representing a fraction less than 1 per cent. of the flowers pollinated.

In the following tabulation the number of flowers treated is given for each variety, together with the number of fruits formed, and also the estimated stand of fruit on the trees.

SELF-POLLINATION OF PLUMS. SPRING OF 1898.

Tabulation of Hand-pollinated Set.

	When pollinated.	No. of flowers.	Fruits Jun. 6 Good.	Fruits Jun. 6 Imp.	Fruits June 23.	Stand of fruit estimated.
American Eag'e	May 14	16	2	2	1	light
Apricot.......... ..	" 17	7	0	1	0	medium
Cheney..............	" 14	8	0	5	0	very light
Colorado Queen......	" 14	13	5	2	1	medium
Comfort	" 14	4	0	0	0	very light
Cottrell	" 18	18	10	2	0	medium
Deep Creek..........	" 14	23	0	1	0	medium
Deep Creek..........	" 17	19	0	0	0	medium
Forest Rose..........	" 14	17	0	3	0	medium
Hammer.............	" 18	8	4	0	0	none
Harrison	" 14	9	0	6	0	heavy
Hawkeye	" 14	13	4	1	0	medium
Hilltop	" 14	17	0	2	0	very light
Ida	" 14	14	4	3	0	very light
Idall................	" 14	12	0	8	0	very light
Illinois Ironclad......	" 17	23	0	0	0	light
Joe Hooker..........	" 14	10	0	1	0	very light
Kampeska...........	" 14	15	0	4	0	medium
Kickapoo............	" 17	8	5	0	0	medium
Kopp................	" 14	19	0	8	0	medium
Le Duc.......	" 17	14	5	4	0	very light
Leonard.............	" 18	22	8	0	0	very light
Little Blue Damson..	" 17	13	2	1	0	medium
Maryland	" 14	19	0	0	0	very light
Miner	" 18	22	8	0	0	very light
Minnetonka..........	" 18	13	1	2	1	very light
Missouri Apricot.....	" 14	10	2	3	1	light
Moon	" 17	27	9	7	0	light
Ocheeda.............	" 17	15	4	6	0	medium
Peffer's Premium.....	" 17	12	2	6	0	medium
Prairie Flower.	" 18	13	8	0	0	very light
Purple Yosemite.....	" 14	10	6	1	0	heavy
Quaker..............	" 18	20	1	2	0	none
Rockford............	" 17	4	0	0	0	very light
Speer................	" 17	15	4	5	0	very light
Van Buren...........	" 17	34	7	9	2	medium
Weaver	" 14	7	0	0	0	very light
Weaver	" 14	6	2	1	0	very light
Winnebago	" 14	26	2	3	0	heavy
Wolf (young tree)....	" 14	20	0	4	0	heavy
Wyant...............	" 14	26	8	2	0	very light
Yellow Sweet........	" 14	8	0	0	0	very light
		629	113	105	6	

The self-pollinated set embraced 48 clusters containing 699 flowers and represented 41 varieties. At the time the pollen was applied to the flowers of the other set, these clusters were examined and such flowers as then had dead pistils were removed, otherwise they were not disturbed until the count of June 6 was made.

SELF POLLINATION OF PLUMS. SPRING OF 1898.

Tabulation of Set Not Hand-pollinated.

	Number of flowers.	Fruits June 6 Good.	Fruits June 6 Imperfect.	Fruits June 23.	Stand of fruit estimated.
American Eagle......	10	2	2	0	light
Apricot..............	16	0	0	0	medium
Cheney..............	8	0	0	0	very light
Colorado Queen......	19	3	8	0	medium
Comfort	2	0	2	0	light
Cottrell	19	4	4	0	medium
Deep Creek...........	11	0	2	0	medium
Deep Creek...........	12	0	0	0	medium
Forest Rose...........	14	0	2	0	medium
Hammer..............	8	2	1	0	none
Harrison	11	0	0	0	heavy
Hawkeye.............	11	4	1	0	medium
Hilltop	11	0	0	0	very light
Ida	14	1	4	0	very light
Idall.................	15	4	4	0	very light
Illinois Ironclad......	22	0	0	0	light
Joe Hooker...........	15	5	1	0	very light
Kampeska	14	0	2	0	medium
Kickapoo	10	6	2	0	medium
Kopp.................	25	0	8	0	medium
Le Duc	9	3	5	0	very light
Leonard..............	16	0	5	0	medium
Little Blue Damson...	15	7	0	4	medium
Maryland.............	20	0	0	0	very light
Miner	21	8	0	0	very light
Minnetonka	10	0	2	0	very light
Missouri Apricot......	14	0	9	0	light
Moon.................	28	11	8	0	light
Ocheeda.............	18	6	2	0	medium
Peffer's Premium.....	17	4	10	0	medium
Pennock's Hybrid.....	37	0	3	0	light
Prairie Flower........	13	8	0	0	very light
Purple Yosemite......	15	9	6	1	heavy
Quaker	18	1	1	0	none
Rockford	2	1	0	1	very light
Speer	10	3	4	0	very light
Van Buren...........	90	15	18	0	medium
Weaver..............	9	1	0	0	very light
Weaver..............	7	0	0	0	very light
Winnebago	20	0	4	0	heavy
Wolf (young tree)	24	6	6	1	heavy
Wyant...............	15	9	3	0	very light
Yellow Sweet........	4	0	0	0	very light
	699	123	129	7	

It appears from the table that on June 6 there were 123 well formed fruits and 129 imperfect fruits. Or of 699 flowers covered, 14.73 per cent. set good fruits and 15.59 per cent. set imperfect fruits. On June 23 the number of fruits remaining was 7 which represents practically 1 per cent. of the flowers covered.

The number of fruits produced by the hand-pollinated flowers was 6.

In final results, then, there is a remarkably close agree-

ment between the two sets. The natural conclusion is that the infertility did not lie in the failure of the stigmas to receive pollen, but must be looked for either in an inherent antipathy which the plant has for its own pollen or in some outside influences. One factor comes in here which makes the test unsatisfactory, and prevents drawing definite conclusions as to the cause of the infertility, and that is the extent of the "June drop" from all parts of the trees. This was so great that even the trees that set full, matured but a light crop. The same influences acting upon the covered flowers would account, in part at least, for the results recorded. Further discussion of the cause is reserved until additional observations suggested by the work this year can be made.

INSECTS AND DISEASES.

INSECTS.

The insects commonly injurious to the plum, such as the Plum Gouger, Curculio and Plum Aphis are treated in bulletin No. 47 by Prof. Gillette, and for information concerning them the reader is referred to that bulletin.

FUNGUS DISEASES.

There are several parasitic fungi reported from different parts of the country as injurious to the plum. At least four of these are present in Colorado, although only two have thus far worked to an injurious extent upon the cultivated plums. The fungus at present doing greatest injury, and having widest distribution, is the Leaf-spot or Shot-hole fungus (*Cylindrosporium Padi Karst*). It has been present in the station orchard for four seasons, but has been controlled by spraying so that no serious injury has resulted from it.

The disease makes its appearance early in the summer or about the time the leaves reach full size. Small circular spots of a red or purplish color are first seen; these enlarge somewhat, becoming an eighth of an inch in diameter. As

the fungus matures the spots become dark brown, shading to light brown at the center. The effected tissue shrivels, and finally drops out, leaving circular holes. Frequently several spots may run together so that the holes left in the leaf are irregular in form. Under conditions favorable to the fungus the spots become so numerous as to destroy the leaves attacked, and thus check the growth of the tree, and prevent the development of fruit. If stocks in nursery are attacked the bark tightens and the stocks cannot be budded. The injury to orchard trees by this disease is in direct proportion to the percentage of leaves destroyed, but no matter how slight the attack it should receive attention. The tree is entirely dependent upon the leaves for the elaboration of its food, and any injury to them that interferes with the fulfillment of this important office, checks growth and injures vitality.

Various remedies have been tried and of these the Bordeaux mixture gives the most general satisfaction. In our practice with this remedy we have made two applications; the first as soon as the leaves are developed, and a second about three weeks later. In some seasons a third and possibly a fourth application may be necessary, as the development and spread of the fungus is in a measure dependent upon weather conditions. The appearance of leaves attacked by this fungus is shown in Plate III.

POWDERY MILDEW OF THE PLUM AND CHERRY.

(*Podosphæra oxyacanthæ* (DC.) DBy.)

This disease has not appeared in the station orchard, but has been reported to us from two counties of the state as injurious to both plum and cherry trees. The fungus works entirely on the surface of the leaves, drawing its nourishment from the cells by means of minute suckers called haustoria. Badly effected leaves appear as if dusted with a white powder and this suggested the common name. Being on the surface the fungus is easily reached by any of the fungicides in common use. Finely powdered sulphur, which has been successfully used in combatting the closely related Powdery Mildew of the Grape, would probably be equally effective in destroying this parasite. The fungus does not usually appear until late in summer; our specimens were received the last week in August.

BLACK KNOT. (*Plowrightia morbosa.* (Schw.) Sacc.)

The fungus causing Black Knot has proved destructive to plums and cherries in many of the eastern states. It has not, so far as my information goes, attacked cultivated plums in Colorado, but from its presence as a common disease of the wild plums of the foothills, it seems likely that it may at any time appear in orchards.

Black Knot has been known as a disease of plums for a long time, but the cause was for many years a mystery. The larvæ of insects being commonly found in old knots, led many to believe that the trouble was due to them, but entomologists proved that the larvæ found were only using the abnormally developed tissue as food and had nothing to do with its production. The fungus was named as early as 1821, but discussion regarding the true cause continued until Dr. Farlow,* of Cambridge, worked out the life-history of the fungus and established beyond controversy that it was the cause of the trouble.

The presence of the disease is first seen in swellings on twigs; these are due to an abnormal growth induced by some irritative action of the fungus threads. As development proceeds the bark is ruptured, the exposed inner surface becomes covered with spore bearing threads, and assumes a greenish-brown color. These spores are carried by winds and insects and serve to infect other branches or trees. The knot continues to enlarge, becomes hard and changes to a brown and finally black color. Later in the fall cavities form in the tissue of the knot and in these are produced a second form of spores which may escape in spring to further disseminate the fungus. Two other spore forms have been found in connection with the fungus, but further mention of them is not necessary here. The threads of the fungus are perennial within the tissues of the plant, and when once started, growth will continue until the tree dies. While spraying at the proper time may be of use in preventing spreading to other trees, the only effective remedy for trees attacked, is to cut and burn the knots as soon as discovered. One of the characteristic knots is shown in Fig. 1, Plate 4.

* Bulletin Bussey Institution Part V pp. 440-453 (1876).

PLUM POCKETS. (*Exoascus Pruni Fckl.*)

This disease is quite common on the wild *Prunus Americana* of the foothills, but no case of attack upon cultivated varieties has come to my notice. The effects produced by the growth of this fungus are perfectly characteristic. Not long after the fall of the blossoms the young plums begin to enlarge rapidly; they become spongy or bladdery, and may vary in size from one-half inch to an inch and a half in diameter. In color they are pale green or yellowish. By the middle of June they shrivel somewhat, becoming wrinkled, and finally drop. Sometimes only a portion of the fruits on a tree are effected and again no normal fruits can be found. The fungus sometimes attacks the leaves and young twigs, but more commonly the fruit only is effected. From observations on wild plums it appears that trees once infected continue to produce pockets each year, and it is doubtful if these trees can be cured; but spreading to other trees can be prevented by gathering and destroying the pockets before the spores are discharged. Where the disease attacks cultivated plums it seems to be quite local and does not spread rapidly. It is never epidemic and there seems to be little danger of serious injury from it. Plum pockets as they occur on the wild plum are illustrated in Fig. 2, Plate 4, which was photographed from a dry specimen.

A BLIGHT DISEASE.

Late in the summer of 1897 twelve trees in the orchard were attacked by a blight, the nature of which is obscure. The leaves began turning brown at the edges; this spread, involving the whole leaf surface and the trees died. Examination failed to reveal the presence of fungi, and it seems most probable, from the appearance and development of the disease, that its cause must be sought in some bacterium. The disease, while possessing the same general nature as pear blight, is certainly distinct from it. The trees attacked were all old and in bearing. No young trees suffered, and there was no reappearance of the disease this season.

VARIETIES.

The following notes on varieties are based almost wholly upon observations made in the station orchard.

This orchard, as originally set, contained the following varieties:

Coe's Golden Drop.	Prairie Flower.
Wolf.	Marion.
Russian No. 2.	Forest Garden.
Miner.	Little Blue Damson.

We have no record of the planting, and do not know the year, or the original number of trees, or the source from which they were obtained. The original planting is now represented by 1, Coe's Golden Drop; 29, Wolf; 1, Russian No. 2; 10, Miner, and 9, Prairie Flower.

The following additions have been made: In 1894, 57 varieties; in 1895, 10 varieties; in 1896, 1 variety; in 1897, 62 varieties; in 1898, 31 varieties. The total number of varieties planted for trial is 169. Seventeen varieties have been lost through winter-killing, so that there are now living representatives of 152 varieties. Some of these give no promise of value and will be discarded. The number that have proved suited to our conditions is not large, and nearly all of them are of the American group. Detailed descriptions are given only of those varieties that are fruited. A few others are briefly mentioned.

AMERICAN EAGLE. (*Prunus Americana.*)

Represented by nine trees planted in the spring of 1894. Trees well formed, spreading in habit, of moderate vigor. Leaves large; young stems and petioles densely puberulent. Bore heavily in 1897, followed by a light crop in 1898. Fruit large, round-oblong, dark red or mottled with small yellow spots; stem of medium length; skin thick; flesh firm, reddish yellow, of excellent quality. Stone rather small for the size of the fruit, cling, rounded at apex, prolonged into a sharp point at stem end, strongly convex on the sides, margin sharp, but not otherwise prominent. Ripe September 20.

APRICOT. (*Prunus Americana.*)

Planted in 1894. Of bushy habit, forming a close, compact head. Leaves large, broad, sharply serrate, stalks pale red, pubescent. Fruit medium in size, round-oblong, color red, where shaded mottled red on yellow ground, bloom slight; suture inconspicuous, skin thick; flesh reddish-yellow, quite firm, juicy, sweet and of good flavor when fully ripe. Stone cling, rather large, flat, moderately pointed at both ends, no prominent margin, roughish. Ripe September 4.

BOTAN. JAPANESE GROUP. (*Prunus triflora.*)

Our trees were planted in 1897 and have not yet had sufficient test as to hardiness. They have made a vigorous growth and are now well set with fruit buds. Leaves of medium size, glossy, light green, sharp-pointed at both ends; stalks short and stout.

BURBANK. JAPANESE GROUP. (*Prunus triflora.*)

Trees planted in 1897 bore a few fruits this season. Habit of growth upright, very vigorous. Leaves of medium size, broadly lanceolate, short acuminate, stalk short and stout. Fruit large, peach-like in shape; color deep red, on yellow ground, which appears in small spots; flesh firm, deep yellow; suture evident; stone small, semi-cling. Ripe September 12.

CHAMPION. (*Prunus Americana.*)

Trees planted in 1894 have made a vigorous spreading growth, smooth, less thorny than most members of the group. Leaves large, light glossy green, strongly recurved, stalks red, short, somewhat pubescent. Not yet fruited.

CHENEY. (*Prunus Americana.*)

Planted in 1894. Very vigorous in growth and upright in habit, producing no virgate drooping branches; quite thorny; leaves obovate, acuminate, three to five inches long, veins prominent, pubescent below, light green, leathery in texture, stalks stout, about an inch long; fruit large, somewhat oblique, pointed or rounded at apex; stem short, stout, set in a large cavity, suture evident; color dull red, mottled on a greenish-yellow ground; stone cling; skin thick, flesh firm, sweet, of good flavor. Ripe September 4. One of the most promising of the Americana varieties. Fruit fig. 1, plate V; tree, plate VIII.

CHOPTANK. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees planted in 1894 have made a vigorous growth each year, and have regularly killed back nearly to the ground each winter. Evidently too tender for this locality.

CLARK. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees well formed and of moderately vigorous growth. Kills back at the tips each year. Leaves of medium size, rather broad for the species; fruit of medium size, nearly spherical, but somewhat irregular; color red in the sun, shading to light red on green ground in the shade; suture distinct; flesh firm, orange-red, very acid; stone cling. Ripe Aug. 30. The quality of the fruit does not commend the variety.

CLINTON: MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894. A vigorous grower, but has killed back repeatedly; worthless here,

COE'S GOLDEN DROP. (*Prunus domestica.*)

This well-known English variety is perfectly hardy in tree, but the fruit buds are yearly killed to such an extent that it is not at all productive. Trees are upright in habit and of slow growth. Leaves of medium size, dull dark green, obtusely crenate, stalks glandular, pubescent, as are also the lower surfaces of the leaves; young wood dark purplish-red, glabrous. Fruit large, roundish-oblong, projected into a slight neck, and indented at insertion of stem, suture deep, sides somewhat unequal; color pale yellow or greenish; flesh firm, of excellent quality; stone free, nearly straight on one edge, curved on the other, margin irregular, sharp, rough. Ripe September 20.

COLORADO QUEEN. (*Prunus Americana.*)

Trees planted in 1894 are well formed and of vigorous growth, much inclined to the production of long drooping or pendulous branches. Leaves of medium size, broad, sharply serrate, light green, stalks slender, young wood light colored, glabrous. Fruit below medium in size, spherical, slightly indented at lower end; color dark purplish-red over yellow ground which shows as small dots; suture hardly apparent; stem long, rather stout; skin thin, flesh juicy, subacid, of fair quality; stone circular, convex. Ripe September 4.

COMFORT. (*Prunus Americana.*)

Of slow growth and straggling habit, very thorny, producing many drooping branches; leaves of medium size, ovate-lanceolate, sharply and irregularly serrate, stipules large and rather broad, soon falling. Hardy. Although planted in 1894 the trees have not yet fruited.

COTTRELL. (*Prunus Americana.*)

Planted in 1894. Trees vigorous, but irregular in habit, hardy; young wood brownish-red, glabrous; leaves above average size, dull light green, broad, coarsely and irregularly serrate; stalks glandular, rather short and stout, red, pubescent. Fruit medium to large, round-oblong, color red, nearly uniform, on lemon-yellow ground, and covered with a thin rosy bloom; skin thin, flesh firm, of superior flavor; stone semi-cling, large, smooth, elliptical with a prominent rounded margin, convex portion relatively small; stalk long, slender. Ripe September 14. Quality and productiveness place this among the desirable varieties.

DEEP CREEK. (*Prunus Americana.*)

Our trees were planted in 1894 and 1895. They are inclined to be irregular in habit and are of slow growth as compared with Weaver or Cheney. They are very thorny and in general appearance resemble wild trees; young wood glabrous. Leaves large, oblong-lanceolate, coarsely and bluntly serrate, stalks red, slightly pubescent, rarely glandular. Fruit small to medium, roundish or slightly oblong; suture apparent, or in some fruits inconspicuous; color uniformly deep red when fully ripe, bloom abundant; stem of medium length, slender; skin thick; flesh firm, juicy, sweet when ripe; stone semi-cling, oblong, sides strongly convex, pointed, smooth. Ripe August 30. Fairly productive. Trees planted in 1894 bore a light crop in 1896, a heavy crop in 1897 and a light crop in 1898. Fruit fig. 2, plate V; tree, plate IX.

FOREST GARDEN. (*Prunus Americana.*)

Tree typical of the class; leaves of medium size, light green, sharply serrate, the teeth overlapping, stalks reddish, nearly glabrous, glandless. Fruit medium in size, round;

color dark purple-red; stem long, slender, skin thick; flesh moderately firm, of sub-acid flavor; stone semi-cling, rounded at lower end, sides convex, prolonged into a flattened point at upper end, roughish. Ripe September 16. Tree a heavy bearer.

FOREST ROSE. MINER GROUP. (*Prunus hortulana* var. *Mineri*.)

Represented by two station-grown trees. They were grafted in the spring of 1894, one on Myrobalan stock, the other on Americana stock; grown one year in nursery and set in orchard in 1895. Both fruited in 1897. The trees are alike except that the one on Myrobalan stock is slightly larger than the other. Both are of good form and vigorous growth. Leaves medium, rather broad, dull light green, sharply serrate; stalk slender, puberulent, glands commonly wanting. Fruit medium in size, round, or somewhat oblique, dark red on yellow ground which shows as minute dots; stem long, slender; skin thin, suture obsolete, flesh firm, sweet and of fine flavor; stone cling, circular, but drawn into a point at the upper end, somewhat rough. Season medium, ripe September 4. A good and productive variety. Fruit fig. 1, plate VI; tree, plate X.

GARFIELD. WILD GOOSE GROUP. (*Prunus hortulana*.)

Trees planted in 1894 have killed back so badly each winter that we may class this as too tender for this locality.

HAMMER. (*Prunus Americana*.)

Four trees planted in 1894 are of erect habit, but of slow growth, nearly free from thorns. Kills back at the tips to some extent and has not fruited. Leaves large, oval-oblong, doubly crenate, light green, flat, stalks glandular; young wood light-red, glabrous.

HARRISON. HARRISON'S PEACH. (*Prunus Americana*.)

Trees of moderate vigor, forming round symmetrical tops; hardy. Leaves large, broad, margins loosely crinkled, very irregularly and sharply serrate; stalks stout, glandular, densely puberulent. Fruit medium to large, round-

oblong; color light red on a translucent light yellow ground, covered with a thin rosy bloom; stem long, slender, skin thick; flesh rich, juicy; stone cling, rather long pointed, convex on the sides, smooth. Season medium; ripe September 11. A promising variety.

HAWKEYE. (*Prunus Americana.*)

Trees planted in 1894 are well formed and vigorous, but not quite as large as those of Wolf, Weaver or Cheney of the same age. Leaves large, obovate, glossy green, sharply and irregularly serrate. Fruit large to very large, round, slightly flattened; color dark red shading to light red on yellow ground, which shows as conspicuous dots; bloom thin, suture apparent; stem stout, of medium length; skin thick; flesh very firm; flavor excellent, sub-acid; stone cling, very large, round oval, very flat, rough. Ripe September 18. A desirable variety. Plate XI.

HILLTOP. (*Prunus Americana.*)

A vigorous variety of spreading habit. Leaves medium to large, obovate, acuminate, irregularly serrate, leathery in texture, pubescent below; stalks red, pubescent, usually glandless. Trees were planted in 1894, but have not yet fruited.

HOLT. (*Prunus Americana.*)

Planted at the same time as Hilltop and resembling that variety in vigor and habit. Trees killed back slightly during the winter of 1895-6. Leaves large, acuminate, sharply and irregularly serrate, upper surface crimped, stalks glandular. Not yet fruited.

IDA. (*Prunus Americana.*)

Trees planted in 1894. Very thorny, of slow irregular growth; young shoots somewhat pubescent; leaves large, broadly ovate-lanceolate, irregularly serrate, leathery in texture; stalks glandless or occasionally with a single small gland. Fruit of medium size, round oblong; suture evident; color mottled and shaded with red on yellow ground, stem of medium length, stout; skin thick, flesh pale yellow, in-

ferior in flavor; stone cling, roundish, rather flat, blunt at both ends, with no prominent margin. Season medium to late. Ripe September 18. Fairly productive.

IDALL. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894 have passed through four winters without injury and are apparently perfectly hardy. They are vigorous and have formed symmetrical heads. Leaves large, obovate, doubly serrate, dull dark green, stalks glandular and pubescent. Not yet fruited.

ILLINOIS IRONCLAD. (*Prunus Americana.*)

Planted in 1894. Growth slow. Trees much smaller than those of Wolf and Weaver of the same age. Leaves large, dark green, sharply doubly serrate, the veins pubescent below; stalks red, pubescent, glandular. Fruit of medium size, oblong, truncate at base, cavity large and deep, suture inconspicuous; stem long, stout; color red on lemon-yellow ground; stone cling, oval, flat, no prominent margin or point; flesh firm, sub-acid, of good flavor. Season medium to early; ripe September 6.

INDIANA RED. MINER GROUP. (*Prunus hortulana* var. *Mineri.*)

Trees planted in 1894 have killed back every year and the variety is classed as too tender.

JOE HOOKER. (*Prunus Americana.*)

Trees of moderate vigor, forming well-shaped heads, but showing a tendency to the production of long drooping shoots. Leaves rather small, ovate-oblong, stalks slender. Fruit medium to small in size, roundish-oblong; color red on yellow ground. Ripe September 11.

KAMPESKA. (*Prunus Americana.*)

Trees planted in 1894. Growth stocky and slow, branches stiff. Leaves below average size, light green, obovate, sharply acuminate and very sharply serrate; stalks

pubescent, glandular. Fruit small, round, dark purplish-red, bloom rather thick, stem of medium length, stout; skin thick; flesh of fair quality; stone semi-cling, oval, strongly convex on the sides, sharp on the edge but not margined. Ripe September 11. Tree productive, but fruit too small to be ranked as valuable.

KICKAPOO. (*Prunus Americana.*)

Planted in 1894. Not yet fruited. Trees of slow growth and straggling habit. Leaves large, broadly lanceolate, sharply and irregularly serrate, stalks glandular.

KOPP. (*Prunus Americana.*)

Trees of good form and fair vigor, producing some drooping branches. Leaves large, dark green, sharply serrate; stalks red, pubescent, mostly glandless. Fruit medium to small, round, deep red, shading into the green ground, this mottled with white dots; skin thick; flesh firm, of good sub-acid flavor, sweet when fully ripe; stone nearly free, oblong, pointed, strongly convex, smooth. Ripe September 1. A productive variety.

LATE ROLLINGSTONE. (*Prunus Americana.*)

Trees of moderate vigor, forming round compact heads. Leaves of medium size, obovate-oblong, short acuminate, irregularly and unequally crenate; young shoots red, smooth, shining; stalks glandular, pubescent. Fruit medium in size, round, flattened at both ends, deep red, shading into light red; stem of medium length; skin thick; flesh firm, of excellent quality. Stone cling, broad-oval, sides moderately convex, smooth. Ripe September 11. Not to be distinguished from Rollingstone. Even in time of ripening there appears to be no difference here.

LE DUC. (*Prunus Americana.*)

The trees planted in 1894 are still rather small, but stocky and well-formed; they fruited heavily in 1897. This year they bloomed full, but matured a very light crop. Leaves large, light green, sharply serrate; stalks glandular.

MISSOURI APRICOT. WILD GOOSE GROUP. (*Prunus hortulana.*)

Trees grown at the station and set in orchard in 1895; fruiting first in 1897. Of moderate vigor, inclined to be irregular in habit. Leaves of medium size, ovate, coarsely and sharply serrate, pubescent below; stalks glabrous, mostly glandless. Fruit medium to large, roundish, slightly narrowed at stem end, truncate at apex, sometimes indented, stem long; color waxy yellow with red cheek next the sun, mottled all over with small light-colored dots; flesh firm, sweet, rich; stone cling, short and broad, rounded at apex, pointed at stem end, sides convex. Ripe August 29. One of the desirable varieties.

MOON. (*Prunus Americana.*)

Trees planted in 1894 bore a few fruits in 1896, a heavy crop in 1897, and a light crop in 1898; they are not vigorous in appearance, and grow very slowly; young branches light colored; leaves medium in size, obovate, coarsely and irregularly serrate, stalks glandular. Fruits medium, round or slightly oblong, deep red or mottled on yellow ground, suture obsolete; skin thin, flesh moderately firm, of good flavor, sub-acid; stone cling, short oval, strongly convex, with no prominent margin. Ripe September 5.

OCHEEDA. (*Prunus Americana.*)

Trees of slow growth, forming round tops and producing many drooping branches, very thorny. They were planted in 1894, began bearing in 1896, gave a good crop in 1897 and a medium crop in 1898. Leaves large, oblong, acuminate, dark green, sharply and deeply serrate, pubescent below; stalks glandless or occasionally with two small glands, red, pubescent. Fruit of medium size, round-oblong; red on lemon-yellow ground with thick bloom; stem long; skin thick, flesh firm, of good flavor; stone cling, large, long-pointed, strongly convex on the sides, margin sharp, surface smooth. Ripe September 11.

OGON. JAPANESE GROUP. (*Prunus Americana.*)

Trees of very vigorous growth, but killing back to such extent each winter that they have borne no fruit. Young twigs light-colored, outer bark on two-year-old wood greenish-brown, showing many lenticles and cracks, on older wood becoming dark colored. Leaves lanceolate, glossy, light-green, crenate and glandular-denticulate; stalks short, glandular. Top grafts on native *Prunus Americana* inserted in 1894 have fruited for four seasons. Our description of the fruit is drawn from specimens produced in 1897. Round-oblong, slightly flattened at apex, oblique at stem end, cavity rather shallow; suture inconspicuous; color dull yellow with thin whitish bloom; stem short, stout; stone free, oval, sides strongly convex, margin prominent and sharp; flesh thick, firm, meaty, of inferior quality. Ripe Augt 14. Plate XII.

PEFFER'S PREMIUM. (*Prunus Americana.*)

Trees planted in 1894 are still quite small, but well formed; young wood glabrous. Leaves medium, broadly-ovate, light green, more or less doubly serrate, the teeth short, stalks red, with or without glands. Fruit of medium size, round, rather abruptly flattened at both ends; suture obsolete; color deep red on yellow ground, conspicuously marked by "leather cracks" about the stem end; bloom thin; flesh firm, quality good; stone cling, circular, sides convex, sharp on the margins, smooth. Season medium; ripe September 11.

PENNOCK'S HYBRID. (*Prunus Besseyi* X *Prunus Americana.*)

A few years since, in the nursery of Mr. C. E. Pennock, of Bellvue, there appeared among a lot of seedlings of *Prunus Besseyi*, one tree that, while bearing the flowers of *Prunus Besseyi* had the habit and foliage of *Prunus Americana*. The fruit borne by this tree is nearly the size of wild *Prunus Americana* but in color and flavor like *Prunus Besseyi*. The mixture of characters suggested hybridity and led Mr. Pennock to experiment in that direction. Pollen of *Prunus Americana* was successfully used on the stigmas of *Prunus Besseyi* and several hybrids resulted. These all resemble the plum in habit, but have the small flowers of the cherry. The leaf characters are intermediate, but generally most like the male parent. The fruit of most of the trees is

not valuable, being small and very acid. The color in all is dark, and in general much like the cherry. One tree, however, produces fruits that are considerably larger and much better than any of the others. It is to be introduced and may prove an acceptable addition to the list of varieties. This tree is of spreading habit, in general appearance like varieties of *Prunus Americana*. Leaves medium in size, varying from ovate to lanceolate. Flowers small, produced in profusion. Fruit of medium size, spherical; color deep blue, with light bloom; flesh firm, of excellent flavor, possessing none of the astringency so noticable in the fruit of the other hybrids. The tree in bloom is illustrated by plate XIII, and a branch showing fruit in figure 1, plate XIV. It is worthy of further trial.

PRAIRIE FLOWER. (*Prunus hortulana*, var. *Mineri*.)

Represented by nine old trees of uncertain age, and one tree planted in 1894. The young tree fruited in 1897, the others have born for several years. The old trees are fully developed, as large as the trees of Miner, and of the same appearance. Leaves large, broadly to narrowly ovate-lanceolate, evenly crenate, lower surface pubescent, stalks long, stout, glandular. Fruit of medium size, round-oblong, obscurely pointed; color red on yellow ground, flecked all over with small light dots; suture evident; stem of medium length, stout; skin thin; flesh firm, sub-acid, of fair quality; stone cling, rather broad, short pointed at both ends, margin rather sharp, slightly roughened. Ripe September 21. Very productive.

PURPLE YOSEMITE. (*Prunus Americana*.)

In character of tree very closely resembling the wild plant: very thorny, and irregular in habit. Leaves of medium size, ovate or obovate, acuminate, doubly serrate, dark green, pubescent below; stalks glandless, or occasionally with two small glands. Fruit large, round-oblong, flattened laterally; color deep purplish-red; skin thick; suture obsolete; flesh firm, of fair quality; stone cling, flat, rounded at the ends, rather rough, margins not sharp. Season medium to late. Ripe September 24.

ROCKFORD. (*Prunus Americana.*)

Our trees planted in 1894 are still rather small, but thrifty in appearance, forming round regular tops. Leaves large, coarsely and deeply serrate, short acuminate; stalks dark red, pubescent, mostly glandless. Fruit of medium size, oblong, somewhat pointed, broad at base; color dark red on green ground; skin thin; suture inconspicuous; flesh firm, very acid until quite ripe, then of good quality; stone cling, broad at stem end and tapering to a rather acute, thick apex, sides strongly convex, margin narrow, but sharp. Productive, early; ripe August 31.

ROLLINGSTONE. (*Prunus Americana.*)

Trees typical of the species, well-formed and of fair vigor. Leaves large, broad, irregularly crenate; color dark green, stalks mostly glandless. Fruit large, round, flattened at both ends; deep red shading to pink on yellow ground; stem of medium length, skin thick; flesh firm, good; stone cling, broad oval, sides convex, margins sharp, smooth. Season medium, ripe September 12.

RUSSIAN No. 2. (*Prunus domestica*)

Trees forming roundish heads, and making less growth than other varieties of the same class. Leaves of medium size, broad, dull green, evenly crenate; stalks short, glandless. Fruit of medium size, inclined to be irregular in shape, often more or less constricted at stem end, and sometimes flattened at distal end; suture apparent, more deeply colored than surrounding parts; color deep purple, with heavy blue bloom, stem sout, of medium length; flesh firm, sub-acid; quality only fair; stone free. Season early, ripe August 15.

SPEER. (*Prunus Americana*)

Small, but vigorous trees of spreading habit, producing long, slender branches. Leaves large, broad, acuminate, deeply and sharply serrate, dark green; stalk red, nearly glabrous, usually bearing small glands. Fruit medium in size, round-oblong, often contracted about the stem; suture evident; color purple-red on yellow ground; stem short, slender; skin thick; flesh firm and of good quality; stone cling, short-oblong, rather flat, ends blunt. Season medium, ripe September 17. Very productive.

SUNSET. (*Prunus Americana.*)

This variety originated with Mr. C. E. Pennock, of Bellvue, Colorado. We have one tree planted in 1897 that produced a few fruits this season. The tree is well-formed with a somewhat spreading habit. Leaves of medium size, broadly lanceolate, margin doubly and irregularly crenate, stalks glandular. Fruit medium to large, oval or oblong, stem rather long, slender; color deep red on yellow ground, beautifully shaded as it approaches ripeness; suture apparent; flesh firm, of excellent quality. Early; ripe August 25. The original tree shows great productiveness, which with the handsome appearance of the fruit, and its good quality, recommends the variety as a valuable acquisition. Fig. 2, Plate XIV.

VAN BUREN. (*Prunus Americana,* var. *mollis.*)

Trees of slow growth, appearing like dwarfs; tops well-formed, spreading; leaves broad, doubly serrate, dark green, stalks ashy-pubescent, glandular; fruit of medium size, spherical, suture obsolete; color deep waxy yellow, in part over-spread with light red and having a deep red cheek; stem stout, of medium length; skin thick; flesh sweet and rich; stone free, flat, rather broad, margin sharp but not winged. Ripe September 22. Very productive. One of the most promising varieties. Plate XV.

WEAVER. (*Prunus Americana.*)

Our trees planted in 1894 are larger than those of any other variety planted at the same time. They are vigorous and well-formed. The tendency to produce long slender branches is quite marked in this variety. Leaves large, obovate or oval, acuminate, somewhat pubescent below, leathery in texture, dark green, deeply serrate; stalk long, stout, glandless, or with occasional small glands. Fruit medium to large, round-oblong; suture evident, sides often unequal; color purplish-red on yellow ground, the red mottled with light dots; flesh firm, sweet when ripe, of good flavor; stone semi-cling, abruptly pointed, smooth. Ripe September 18. Plate XVI.

WINNEBAGO. (*Prunus Americana.*)

Trees very vigorous, well-formed. Leaves large, broad, sharply serrate, produced in great abundance; stalks short, stout, glandular. Fruit medium to small, round, inclined to be irregular and one-sided; stem long, slender, cavity deep; color deep red on yellow ground; skin thin; flesh yellowish, soft, of inferior flavor, granular in texture; stone nearly free, elliptical, somewhat oblique; rather flat, rounded at both ends, roughish. Ripe September 18. Plate XVII.

WOLF. (*Prunus Americana.*)

Vigorous growing trees of spreading habit. Leaves large, ovate, acuminate, closely and sharply serrate, leathery in texture; stalks stout, ashy pubescent; on some trees wholly glandless, on others small glands are not uncommon. Fruit medium to large, round to round-oblong, slightly flattened, sometimes tapering somewhat toward the stem; stem short, stout, set in a small cavity; suture obsolete; color when ripe uniformly deep red, with heavy purple bloom; skin thick; flesh firm, of good quality; stone free, rather small, pointed at stem end, sides strongly convex, margin sharp and prominent, smooth. Season medium, ripe September 16. Fruit Fig. 2, Plate VI; Tree Plate XVIII.

WYANT. (*Prunus Americana.*)

Trees stocky, forming round heads, of slower growth than Wolf or Weaver. Leaves medium, crisp in texture, sharply serrate, dark green; stalks pubescent and glandular. Fruit large, round-oblong, flattened at apex; cavity large and deep; color purple red on yellow ground; stem short, stout; skin thick; flesh firm, of good flavor; stone free or nearly so, large, oblong, flat. Ripe September 18. Fruit Fig. 1, Plate VII.

YELLOW SWEET. (*Prunus Americana.*)

Trees small, stocky, very thorny; leaves large, oval-oblong, irregularly crenate, stalks commonly glandless. Fruit large, round, color yellow, lightly shaded with red, bloom thin; suture apparent; stem short, stout; skin thin; flesh firm, juicy, rich; stone cling, oval, pointed at both ends, sides convex, margin sharp. Ripe August 31. A very promising variety. Fruit Fig. 2, Plate VII; Tree Plate XIX.

REFERENCE TO PLATES.

PLATE I.

Fig. 1, Yellow Sweet; Fig. 2, Wolf, showing lack of affinity between stock and scion. The stock is being overgrown.

Fig. 3, Plate of Weaver plums, reduced nearly one-half.

PLATE II.

Illustrates the system of irrigation practiced.

PLATE III.

Showing the effects of the "Shot-hole fungus" *(Cylindrosporium Padi Karst.)*

PLATE IV.

Fig. 1, Black knot of the plum and cherry, *(Plowrightia morbosa* (Schw.) Sacc.*)*

Fig. 2, Plum pockets. *(Exoascus Pruni Fckl.)*

PLATE V.

Fig 1, Cheney; Fig. 2, Deep Creek; reduced nearly one-half.

PLATE VI.

Fig. 1, Forest Rose; Fig. 2, Wolf; reduced nearly one-half.

PLATE VII.

Fig. 1, Wyant; Fig. 2, Yellow Sweet: reduced nearly one-half.

PLATE VIII.

Cheney.

PLATE IX.

Deep Creek.

PLATE X.

Forest Rose.

PLATE XI.

Hawkeye.

PLATE XII.

A branch of Ogon from top graft on P. Americana.

PLATE XIII.

One of Mr. C. E. Pennock's hybrids between P. Besseyi and P. Americana in bloom.

PLATE XIV.

Fig. 1, Fruit of Mr. C. E. Pennock's hybrid between P. Besseyi and P. Americana.

Fig. 2, Sunset plum, originated by Mr. C. E. Pennock.

PLATE XV.

Van Buren.

PLATE XVI.

Weaver.

PLATE XVII.

Winnebago.

PLATE XVIII.

Wolf.

PLATE XIX.

Yellow Sweet.

Plates 13 and 14 are from photographs by S. H. Seckner, all others from photographs by the author.

PLATE I.

Fig. 1.

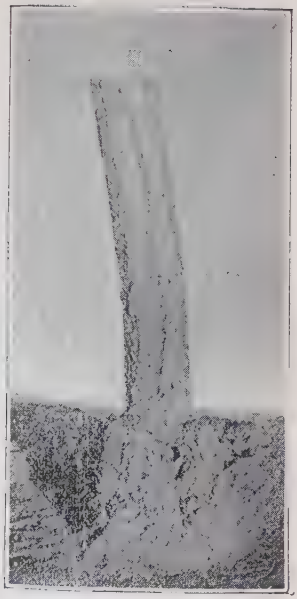


Fig. 2.

Fig. 3—Weaver.

PLATE II.—Irrigation.

PLATE III.

Plum Leaves.

PLATE IV.

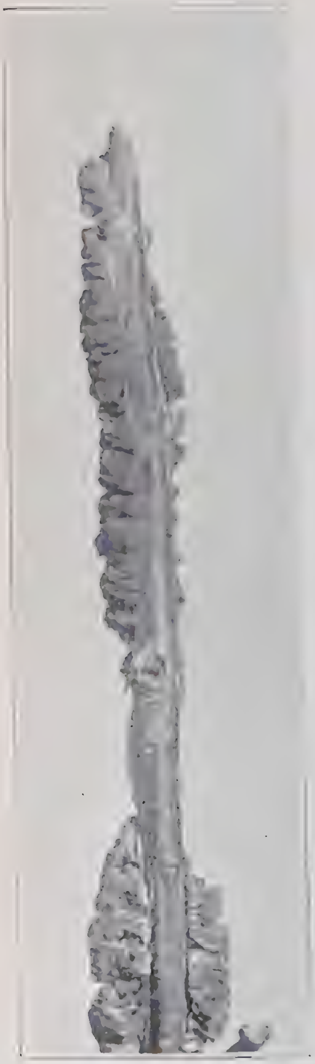


Fig. 1—Black Knot.

Fig. 2—Plum Pockets.

PLATE V.

Fig. 1—Cheney.

Fig. 2—Deep Creek.

PLATE VI.

Fig. 1—Forest Rose.

Fig. 2—Wolf.

PLATE VII.

Fig. 1—Wyant

Fig. 2 – Yellow Sweet.

PLATE VIII.

Cheney.

PLATE IX.

Deep Creek.

PLATE X.

Forest Rose.

PLATE XI.

Hawkeye.

PLATE XII.

Ogon.

PLATE XIII.

PLATE XIV.

Fig. 1—Hybrid.

Fig. 2—Sunset.

PLATE XV.

Van Buren.

PLATE XVI.

Weaver.

PLATE XVII.

Winnebago.

PLATE XVIII.

Wolf.

PLATE XIX.

Yellow Sweet.

THE STATE AGRICULTURAL COLLEGE.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 51.

SUGAR BEETS IN COLORADO IN 1898.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

MARCH, 1899.

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SUGAR BEETS IN COLORADO IN 1898.

By W. W. COOKE.

For several years the Station has been carrying on experiments in Colorado on the adaptation of the sugar beet to the conditions of soil and climate found here. During 1898 these tests were conducted on a larger scale than ever before. It can be said in general that the results of the season of 1898 are so conclusive, that we may feel justified in saying that Colorado can raise as good sugar beets and as large crops of beets as any place in the world. We purpose now to consider this point as settled, and future experimental work with sugar beets will be directed toward some of the minor points of methods of irrigation, times and distances of planting, etc.

The work of 1898 was distinguished from that of previous years in that it was done largely in connection with the Denver Chamber of Commerce, and cash prizes were offered for the best crops of sugar beets, thus affording an incentive to better care of the crop. It is believed that the inducement thus offered was a powerful factor in the good results obtained, yet the value of the prizes was as nothing compared with the value of the crop if raised for a factory. So that it is a fair presumption that what was done under the stimulation of the Denver Chamber of Commerce, prizes would be the common result under factory conditions.

The work of the season of 1898 may be grouped under four headings:

1. The experiments conducted on the College Farm at Fort Collins and on the sub-station at Rocky Ford, with reference to methods of growing sugar beets.
2. Experiments conducted at these two places and at about twenty other places in the State, with reference to the quantity and quality of sugar beets grown from seed raised in the United States as compared with seed grown in Europe.
3. Competitive tests for the prizes offered by the Denver Chamber of Commerce in connection with the County Commissioners of various counties.
4. General tests in the parts of the State above irrigation or in those irrigated sections that did not take interest enough in the matter to co operate in the matter of prizes.

The beet seed was obtained principally from the United States Department of Agriculture, but some, also, from the Oxnard Sugar Co., of Grand Island, Nebraska, through the efforts of the officials of the Union Pacific, Denver & Gulf Railroad; some from the sugar factory at Rome, N. Y., through the efforts of Mr. M. B. Colt, of Alamosa, and when all these sources of supply failed, the Denver Chamber of Commerce bought, in open market, enough seed to supply the remainder of the requests. In all, about four thousand pounds of seed were distributed to two thousand three hundred persons. In each case the seed was delivered free of charge to the person making the tests.

All the analyses on which this bulletin is founded were made by the Chemical Section of the College at Fort Collins. There were eight hundred and twelve samples analyzed at Fort Collins.

Through the courtesy of the U. S. Department of Agriculture the franking privilege was given to the Station for the sugar beet work, and all the seed and several thousand pounds of the beets for analysis were sent through the mail postage free. In addition the railroads of the State, particularly the Union Pacific, Denver & Gulf, Denver & Rio Grande, and Atchison, Topeka & Santa Fe, took a lively interest in the experiments and furnished transportation that materially facilitated the work.

EXPERIMENTS AT FORT COLLINS AND ROCKY FORD ON METHODS OF RAISING SUGAR BEETS.

These tests can be grouped under the following headings:

1. Different dates of planting.
2. Planting on freshly plowed ground as compared with ground plowed a few days before planting.
3. Seed irrigated at planting as compared with that not irrigated.
4. Soaking seed before planting.
5. Sowing at the bottom of a three-inch furrow.
6. Different depths of planting.
7. Transplanting.
8. Different distances of thinning.
9. Different dates of thinning.
10. Variety tests.
11. Number of irrigations.

Each of these tests will be considered by itself, but at the outset it is necessary to make some explanations.

The following general statements apply to all the experiments at Fort Collins. The piece selected was a rather heavy clay loam, sloping slightly to the south. The ground had been heavily manured the spring of 1896 at the rate of nearly sixty tons per acre of well rotted stable manure. It was cropped during 1896 and 1897 with corn. The spring of 1898 it was plowed in sections. A part of the section was planted the day it was plowed, the rest was allowed to lie from two to four days before it was planted. The seed was sown with an ordinary wheat drill in rows twenty-four inches apart. A few rows that will be specially mentioned were sown with a hand garden drill in rows eighteen inches apart. As soon as the beets broke through the ground so as to define the rows, they were wheel hoed by hand. Later they were thinned, hand-hoed, cultivated three times with a horse cultivator, and twice irrigated, on June 27 and July 19.

The first set of samples was taken the last of September, after a period of long continued and severe drought. The last samples were taken October 22. Between these two dates there had been several rains, giving a total precipitation of three-fourths of an inch and dampening the beets to the bottom of the furrow. The beets were dug during the following week, with no further rain. Each of the 176 rows was dug in two parts and each part weighed separately. Every beet on the field was counted, to get the stand under the various conditions, and about half of them were counted the second time. This work involved about a thousand weighings and the counting of over sixty thousand beets.

The plantings at Fort Collins were made May 10, May 27 and June 15, with supplementary plantings May 13 and May 31. It had been expected to make four plantings, but a very heavy snow storm set in the last of April, with a total precipitation of three inches. None of this ran off and the ground was thoroughly soaked to a depth of eight inches. It was not until the second week in May that the soil dried out enough so that it could be worked.

This storm had a far reaching effect on the sugar beet work of the season. It saturated the ground without packing it, and to this is largely due the almost perfect germination obtained and the small influence observed from soaking the seed or irrigating at time of planting. The influence of this storm was still felt at the time of the second planting, the last of May, and the ground was hardly dried out by the last planting, the middle of June. The same storm will be referred to later with reference to its effect on the beets at Rocky Ford.

Before giving the detailed record of the various tests, it may be well enough to notice the analyses of the two sets of samples. Both

sets were taken in the same way. Every tenth beet was taken from two contiguous rows until about a dozen beets had been dug. These were at once topped, cleaned by brushing or scraping, or in a few cases by washing, and weighed on scales accurate to the quarter of an ounce. If they were analyzed the same or the next day no account was taken of the small amount (about two per cent.) that they had dried out between digging and analyzing. If they stood longer than two days before they were analyzed, a correction was made in both total solids and sugar for the water that had dried from the beets after the second day. All of the analyses given in this section on methods of raising beets and in the section of this bulletin on tests of different sources of seed are the corrected analyses after making allowance for the drying out after the second day. In actual factory practice the beets seldom reach the factory until the third day after digging, and often not until much longer periods. So that it is probable that had these beets been raised and delivered to a factory they would have dried out a little more and tested a little higher than the figures given in this bulletin.

About fifty samples were taken the last of September, and an equal number October 22. The average of the first set is 15.43 per cent of sugar in the beet and 78.6 purity. The second set averaged 16.38 sugar and 78.1 purity, thus indicating a small gain in sugar and slight loss in purity between the first and second samplings. If these fifty tests are divided into five sets, according to the dates of planting, as will be given later, the last four sets give 14.97 sugar and 77.2 purity for the first samples, and 16.24 sugar with 77.6 purity for the samples three weeks later. Thus, they show an increase in sugar with but little change in purity. The samples from the first planting average 17.28 sugar and 84.2 purity for the first set, and 16.96 sugar with 79.7 purity for the last samples. A study of the ground gives some explanation of the cause of these differences. The ground first planted was so damp at the time it was worked, that it was somewhat packed by the working, and consequently suffered more from the late drought. At the time the samples were taken, the last of September, the leaves of the beets on this part of the field were so badly wilted as to touch the ground. The beets were really dried out in the ground. When the rain came they absorbed water and showed a lower test, with a change in purity, from a slight second growth.

It can be said, then, that, on the whole, the beets gain one per cent. of sugar during the three weeks between the two times of sampling, but there are so many apparent exceptions to this general statement, due to differences in sampling and analyzing, that it is deemed best to use the analyses of both sets of samples.

1. Different Dates of Planting.

A section of the ground was plowed May 10, part planted at once and the remainder planted May 13. A second section was plowed May 27, and planted on that day and on May 31. The third section was both plowed and planted June 15. The rows were two feet apart and 177 feet long; the intention was to thin to six inches, so as to have one beet for each square foot of surface. In the following table, a "perfect stand" would have been one beet for each six inches of row:

Row.	Date planted	Per ct. of perfect stand.	Average distance apart in row. Inches.	Average weight of beets. Lbs.	Test.	Sugar in beet.	Purity.	Weight of crop in tons per acre.	Pure sugar per acre. Lbs.
21-92........	May 10	....	....	....	First	17.28	84.2	....	......
"	"	....	....	....	Second	16.96	79.7	....	......
"	"	88	6.8	0.92	Average	17.12	82.0	17.8	6095
103-120.......	May 13	....	....	....	First	15.24	74.3	....	......
"	"	....	....	....	Second	17 26	78.8	....	......
"	"	83	7.2	0.90	Average	16.25	76.6	16.3	5296
141-155.......	May 27	....	....	....	First	16.18	79.9	....	.....
"	"	....	....	....	Second	16.54	77.4	....	......
"	"	72	8.3	1.09	Average	16.36	78.7	17.4	5693
156-161.......	May 31	....	....	....	First	15.37	77.3	....	......
"	"	....	....	....	Second	17.05	78.9	....	......
"	"	71	8.4	0.91	Average	16.21	78.1	14.2	4604
165-176.....	June 15	....	....	....	First	13.01	77.5	....	......
"	"	....	....	....	Second	14.11	75.5	....	......
"	"	34	18.0	1.27	Average	13.56	76.5	9.3	2522

For the purpose of studying the effect of the main three different dates of planting, the preceding table may be summarized as follows:

Row.	Date planted.	Per cent of perfect stand.	Average distance apart in row. Inches.	Average weight beets. Lbs.	Per cent of sugar in beet.	Per cent purity.	Weight of crop in tons per acre.	Pure sugar per acre. Lbs.
21-120...............	May 10-13	87	6 9	0.91	16.85	79.3	17.5	5897
141-162...............	May 27-31	72	8.3	1.00	16.31	78.3	16.6	5415
165-176...............	June 15	34	18.0	1.27	13 56	76.5	9.3	2522

The showing against the late planting is very decided. It produced less than half as much sugar as either of the others. It is evident that the small weight of crop is due, primarily, to the poor stand, since, even planting the middle of June, the beets average larger than those planted earlier. But, with only a third of a stand and the beets eighteen inches apart, the extra size did not compensate for the smaller number of beets. The poor stand is due to hot, dry weather, and, as will be noticed more at length in another place, even irrigating at the time of planting did not much increase the germination.

The difference between the crops of the May 10 planting and that of May 27, is not large, indicating that profitable crops may be raised, even though the seed is not planted until the last week in May. The difference in the stand in this case is, undoubtedly, due to the drying out of the ground, rather than to the greater heat. Though differences in sugar and purity are not large, yet these differences are in favor of the earlier planting. The analyses of the beets from the June 15 planting, show that the crop did not reach nearly to the degree of ripeness attained by the earlier plantings.

There is nothing in these experiments to show whether still better returns would be obtained by planting in April, and, unfortunately, the test of this point, made at the Rocky Ford sub-station, was so injured by a severe hailstorm as to offer little light on this point.

The beets at Rocky Ford were planted at four different dates, April 18, May 2, May 16 and June 1. As the season there is about two weeks earlier than at Fort Collins, these dates are about the same, so far as the season is concerned, as those used at Fort Collins, with the addition of one earlier date. The beets were planted in good mellow garden soil, in rows eighteen inches apart and thinned to nine inches apart in the row.

As noted above, a severe hailstorm, on June 6, interfered seriously with the experiment. The plantings of April 18, May 2 and May 16, were well up at the time and were cut even with the ground, allowing the later planting to approach them in growth. When the present writer visited the field, the middle of July, the eye could scarcely tell any difference between the first three plantings.

Two sets of samples were taken of each of these plantings, the first October 8 and the second October 29. The crop was harvested during the next week and the beets counted from several rows of each planting, so as to get the stand and the average size:

Date of planting.	Per cent of full stand.	Average distance apart in row. Inches.	Average weight of beets. Pounds.	Weight of crop in tons per acre.	Pure sugar per acre. Pounds.
April 18	63	9.5	0.96	18.4	6097
May 2..............	57	10.5	0.89	15.1	5138
May 16.............	85	7.0	0.64	15.6	5338
June 1.............	90	6.7	0.50	13 8	4857

Date of Planting.	Test of October 8.		Test of October 29		Average.	
	Sugar in beet.	Purity.	Sugar in beet.	Purity.	Sugar in beet.	Purity.
April 18	16.98	84.6	16.07	86.9	16 57	85.7
May 2	16.79	83.7	17.32	85.2	17.05	84.4
May 16	16.75	86 2	17.47	86.7	17.11	86.4
June 1................ ..	18.02	87.0	17.17	85.5	17.59	86.2

The beets at Rocky Ford ripened better than those on the College Farm. They show for the first three plantings about half a per cent more sugar and more than six per cent. better purity than the first two plantings at Fort Collins. The crops from the earlier plantings at the two places are about equal. But while the last planting at Fort Collins never ripened and produced less than two-thirds the crop of the earlier plantings and not half as much sugar per acre, the last planting at Rocky Ford gives the best beets of all in quality and not much below the others in quantity. At both places the last of May seems to be as late as it is advisable to sow, although a crop can be obtained from beets sown considerable later. The averages of the two sets of samples at Rocky Ford are identical, showing that the beets had fully ripened before the first samples were taken. The intention was to take some earlier samples, but the letter of instructions was lost in the mail.

2. Planting on Freshly Plowed Ground.

One of the greatest troubles in raising sugar beets is getting a good stand. If the seed is planted deep and the planting is followed by a rain, the ground packs and the seed cannot get through; if planted shallow and dry weather follows, the seed cannot get enough moisture to grow well. In the present case, there was a large amount of moisture in the ground at the time of plowing and the question was, will the amount that dries out in the first few days after plowing be enough to influence germination and growth. The table already given contains the figures of the test and the re-

sults are strikingly in favor of planting on freshly plowed ground. In the first case three days elapsed between plowing and planting; in the second case four days intervened. The four items of germination, sugar, purity and weight of crop are in each case in favor of the beets planted as soon as possible after the ground is plowed. These differences are not always large, though in the case of the weight of the crop they amount to one-seventh, but in the aggregate the difference would have a decided influence on the sugar value of the crop. The average of the two plantings on freshly plowed ground is 16.74 per cent sugar, 80.3 purity and 17.6 tons per acre. The beets planted three or four days after plowing give 16.23 per cent sugar, 77.3 purity and 15.3 tons per acre. Combining these figures, the first gives 4731 pounds of available sugar per acre, while the latter yields but 3839 pounds, a difference of nearly a thousand pounds of sugar, or something over ten dollars per acre in favor of immediate planting. In the light of these figures, it can be seen how important it is that if large areas are to be planted, they should be plowed in sections and each section planted the day of plowing.

3. Irrigating at the Time of Planting.

Three tests were made of irrigating the ground as soon as the seed was planted, as compared with allowing the seed to germinate from the moisture in the soil. In each case a small furrow was made some six inches from the seed, and water run in this furrow until it soaked sideways and wet the seed.

Irrigated at Planting.					Not Irrigated at Planting.				
Rows.	Number beets per row.	Tons per acre of crop.	Sugar in beet.	Purity.	Rows.	Number beets per row.	Tons per acre of crop.	Sugar in beet.	Purity.
27–32..........	232	15.8	17.48	84.7	21–26..........	243	16 0	17.84	85 7
45–56..........	338	18.4	17.77	86.4	33–44..........	271	17.8	16.97	84.6
165 170........	112	9.9	12.12	76.5	171–176........	128	8.1	13 08	76.2
Average.....	227	14.7	15.79	82.5	Average.....	214	14.0	15.96	82.2

The results are closer than would be expected had the treatment been exactly alike, showing that so far as these tests are concerned there was no advantage from irrigating up the seed. It should be remembered, however, that this was on a soil very retentive of moisture, and which at the time the first two of these tests were made, was already well supplied with water. This soil also bakes easily and of course the bad effects of the hardening of the soil would go far toward counteracting the good effect of the extra moisture. It was expected that if irrigating up the seed was an ad-

vantage it would show most clearly in the last case, which was sown June 15 after the ground was quite dry. Here, however, the irrigation seemed to be a detriment, due probably to the baking of the soil.

While the above results are not favorable to the practice of irrigating up the seed when sown in ground as heavy as that of the College Farm, it does not follow that this may not be advantageous under other conditions and in other parts of the State. The present writer visited the farm of Mr. B. F. Wyckoff, at Rocky Ford, the past season, and saw there a large field of sugar beets with a perfect stand, that had been secured by irrigating up the seed. This field produced over 23 tons of beets to the acre. At Lamar he saw another perfect field of beets produced in the same way, on the farm of Mr. M. D. Parmenter. On remarking to Mr. Parmenter that at the College our greatest trouble was to get a stand, Mr. Parmenter replied that he always felt perfectly sure of that part of the business. His land was sandy enough so that it would not bake and had plenty of slope. He planted whenever he got ready, and then turned on the water. His perfect stand in 1898 was obtained with about four pounds of seed per acre.

On the lighter soils of the Arkansas valley, irrigating up the seed is a necessity, as the ground will not hold enough moisture to make a complete germination.

4. Soaking Beet Seed.

Two rows were sown with dry seed; two with half each of dry and soaked seed, and two with soaked seed, *i. e.*, seed that had been soaked in water for twenty-four hours before it was planted. Unfortunately, these tests being made on a small scale, were sown with a hand drill that did not do good work. Good results were obtained with the soaked seed, but no better than were obtained on neighboring rows with unsoaked seed. The test shows, therefore, neither advantage nor disadvantage from soaking the seed.

5. Sowing at the Bottom of a Three-Inch Furrow.

It was thought that, adopting the idea of the trench method of raising potatoes, there might be some advantage from getting the beet seed deep in the ground. A small furrow was made with a hand plow, and then the beet seed sown with a hand drill at the bottom of this furrow. This put the beet seed nearly four inches below the surface of the ground, but left it only lightly covered. Three tests were made, including both early and late sowing. The stand was not so good as in the rows on each side sown at ordinary depths. The yield was once as good and twice poorer than from similar rows of ordinary planting. The sugar and purity were not perceptibly different from other plantings.

In connection with this and some other tests, there is a chance to compare the results of planting with a hand planter and a horse planter. Though we have a good hand planter, yet on the whole the horse planter, which with us is an ordinary wheat drill, has given the better stand and the larger weight of crop.

6. Different Depths of Planting.

The following tests were made with the grain drill, set to plant as nearly as possible at the desired depths.

Row.	Depth of planting.	Number beets per row.	Weight of crop per row.	Sugar in beet.	Purity.
57-68	½ inch	360	313	15.51	76.1
147-149............	" "	233	237	16.10	79.0
69-80...............	1 inch	358	281	17.00	78.7
150-152............	" "	239	284	15.78	79.6
81-92..........	1½ inches	315	279	17.31	80.0
153-155............	" "	270	313	16 76	85.0

With the first lot, rows 57–92, sown May 11, there is not much difference, but this slight difference both in stand and yield is in favor of the shallow planting. But it should be remembered that this seed was put into thoroughly damp, freshly plowed ground that was over a damp, almost wet, subsoil. The analysis is enough in favor of the deeper plowing to make the available sugar per acre the same for all three depths of planting.

At the later planting, May 27, rows 147–155, the ground was freshly plowed but had dried out considerably since May 11. In this test the stand, yield and quality are all in favor of the deepest planting, amounting in the comparison of the half inch with the one and a half inch to more than a third of the crop.

7. Transplanting Beets.

Some beet seed was sown in the greenhouse April 20 and the young beets transplanted to freshly plowed ground May 10. The rows were 18 inches apart and the beets 9 inches apart in the row. In the first part of the rows about three fourths of the beets lived, but less than half of them in the rest of the rows, making an average of about one beet to each two square feet. The growth of the beets was satisfactory so far as weight was concerned. They averaged a little over one and a half pounds each, or 16.3 tons per acre. Not a single tap root grew in the whole four hundred beets; they were a mass of fibrous roots that lost at least a fifth in trimming. Their quality was the lowest of all the beets planted early in May, being 14.44 sugar and 74.3 purity.

The above beets were planted in damp ground without irrigation. The next day some more from the same lot were transplanted and irrigated as soon as set. The stand was even poorer than before, though it was supposed that the work had been done with greater care. The size of the beets and the quality were the same as in the first lot. The fibrous roots were not quite so numerous, but there was not a good beet in the whole lot. Seed was sown in the ground at this date, May 10, and on June 8 some of the small beets were transplanted to some neighboring rows. They grew poorly and not one-fourth of them lived. They were not so bad in shape as those from the greenhouse and the quality was better, but as a method of raising beets it proved a financial failure.

Transplanting from the greenhouse, both with and without irrigation, was tried on another lot of plants May 26. It was a hot day, and in spite of the immediate irrigation only a few of the beets lived.

On June 15 transplanting was again tried with some larger beets that had been sown in the ground May 13. These beets were set in running water, and though in the middle of the summer at least nine-tenths of them grew. They were far from good shaped, but they made a crop of 19.3 tons per acre, testing 15.91 sugar, with 79.7 purity.

On June 27 some more transplanting was done from the beets sown May 27. These beets were quite small. They were planted in running water and nearly all grew. They made a crop of 18.9 tons per acre, testing 17.00 sugar with 80.1 purity. Judged by yield and test, these beets show quite well, but they were not good shaped. They were transplanted with the greatest of care into running water and afterwards irrigated several times, so as to give the best possible chance. Better results could hardly be expected, but the method would not be a financial success.

8. Different Distances of Thinning.

The attempt was made to thin beets to 4 inches, 6 inches and 8 inches, but the thinning was so poorly done that the 4-inch and the 6-inch each averaged 8 inches apart, and the 8-inch rows averaged 10 inches apart. Three trials were made. The first two tests on beets planted May 10, show no regularity of results and only slight differences. The 4-inch and 6-inch rows are excellent duplicates. By combining these two and comparing with the other rows, there is a slight showing in favor of the first two in yield, sugar and purity, which leads one to judge that 8 inches is a better distance than 10 inches for two-foot rows. The late planting of May 27 is quite decidedly in favor of the thicker stand for yield, sugar and purity. The full figures are given below:

Row.	Intended distance apart. Inches.	Actual distance apart of beets. Inches.	Number of beets in One row.	Weight of crop in tons per acre.	Sugar in beet.	Purity.
21 and 24	4	8	301	16.1	16.97	79.8
27 and 30	4	8	251	15.6	18.31	86 0
103 and 104	4	8	272	16.5	16.52	75.1
22 and 25	6	8	215	16.5	17.63	83.0
28 and 31	6	8	251	15.5	17.55	83.2
105 and 106	6	8	293	14 9	16.54	78.3
Average.............	....	8	264	15.8	17.26	80.9
23 and 26	8	10	211	15.5	18.38	80.3
20 and 32	8	10	196	16.2	17.03	81.5
107 and 108	8	10	198	13.4	15.12	68.7
Average.............	....	10	202	15.1	16.69	78.6

Seeing that this form of the test was a failure, another trial of the same point was made by going through the rows that were intended to have the beets 4 inches apart and selecting twelve beets, each of which was just four inches on each side from the next nearest beet. The same was done with the 6 inch rows and the 8-inch rows. The following results were obtained :

Row.	Distance apart of beets Inches.	Average weight of beets. Pounds.	Weight of full stand in tons per acre.	Sugar in beet.	Purity.
21 and 24...........	4	1.12	36.6	17.58	80.6
22 and 25...........	6	1.01	22.0	17.67	79.9
23 and 26...........	8	1.21	19.8	18.34	80.3

The beets at 8 inches apart are a little heavier than the others, and this is about the only noticeable difference. The generally accepted belief is that these beets at 8 inches apart should be poorer in quality than those growing closer together. In this particular case they are a little better. The most noticeable result is the computation on a full stand. If a field had a complete stand of beets four inches apart and of the same size as these, it would yield 36.6 tons of beets. While, at 6 inches apart, the yield would fall to 22.0 tons, and at 8 inches, to 19.8 tons. Judged in this way, the results are favorable to the thicker stand.

Lastly, a third test of the same point was tried with rows 27 and 30, that had been intended to be thinned to four inches apart, by selecting from the two rows twelve beets 4 inches apart on each side, another twelve beets from the same rows 6 inches apart, and a third twelve beets from the same rows 8 inches apart:

Row.	Distance apart of beets. Inches.	Average weight of beets. Pounds.	Weight of full stand. in tons per acre.	Sugar in beet.	Purity.
27 and 30..........	4	0.73	24.0	17.71	76.3
27 and 30..........	6	0.89	19.5	17.10	81.2
27 and 30..........	8	1.08	17.8	18.15	80.7

The differences in weight, owing to the different amount of space occupied by each beet, is quite noticeable, but the beets having the most room do not grow correspondingly larger in size, *i. e.*, the beets eight inches apart are not twice as large as those four inches apart, hence the weight of crop per acre is again in favor of the closer stand. The differences in the analyses are not great, but, here again, the larger beets test slightly better than the smaller beets.

Combining the five sets of tests, it can be said that, as a whole, they show that the distances apart of the beets, from four inches to ten inches, has but slight influence on the quality of the crop as to sugar and purity. It can also be said that it has some effect on the weight of the crop, and, if the stands are equal, more tons per acre will be raised at less that eight inches apart than at over this distance. Even this latter statement can be given as only a general tendency, liable to many exceptions. Rows 57–92 were sown under as nearly as possible like conditions, were all thinned by the same person at nearly the same time, and the thinning was intended to be to six inches. As a fact, the rows vary from an average distance of four inches between the beets to more than eight inches. If, now, there are selected the four rows with the greatest number of beets and the four rows with the least, the following results are obtained: The crop from four rows, 708 feet long, with 1,711 beets, or an average of five inches apart, weighed 1,199 pounds; the other four rows of the same length, with 1,137 beets, or eight inches apart, yielded 1,191 pounds. So that, in this case, the beets grew in size exactly proportional to the space they occupied.

To get still further light on the question of the relation of size and quality, a test was made with row 53. The whole row was dug and the six largest beets selected, also six of medium size and the six smallest.

Size.	Average weight of beets. Pounds.	Total solids in juice.	Sugar in beet.	Purity.
Largest..........................	1.73	21.87	16.34	78.6
Medium..........................	0.85	23.27	17.33	78.8
Smallest..........................	0.30	24.53	19.15	82.5

The above results show that in these extreme cases, the smaller the beets the better the sugar and purity. Even here, however, the difference is not large, being, in both cases, about one per cent of sugar for doubling the size of the beet. The previous tests seem to indicate that, for sizes from three-quarters of a pound to a pound and a half, the size of the beet has but little influence on its quality.

9. Different Dates of Thinning.

Most rules for the culture of sugar beets say that the thinning should be done as early as possible. Four tests were made to note the effects on the quantity and quality of the crop of thinning at different dates. The earliest thinning was done when the plants were quite young, from 18 to 26 days after planting, while the last thinning was 29 to 40 days after planting. These are not very wide extremes, but they cover the time at which most of the thinning would be done in beets raised for a factory.

No. of Test.	Date of thinning.	Days from planting to thinning.	Number of beets per row.	Weight of crop in tons per acre.	Sugar in beet.	Purity.
1....................	June 6	26	260	16.7	15.90	77.4
2....................	" 6	26	363	19.0	17.54	83.1
3....................	" 8	26	385	17.4	17.22	81.0
4....................	" 14	18	241	17.1	16.59	85.4
Average	....	24	312	17.5	16.82	81.7
1....................	June 16	36	297	17.0	16.77	81.8
2....................	" 16	36	283	17.3	17.08	83.5
3....................	" 16	34	283	16.4	....	....
4....................	" 17	21	270	20.3	15.76	75.0
Average...........	....	32	283	17.7	16.54	80.1
1....................	June 20	40	268	16.8	17.22	85.3
2....................	" 20	40	305	17.7	18.43	85.1
3....................	" 20	38	327	15.5	16.00	78.0
4....................	" 25	29	288	18.7	17.31	81.6
Average	....	37	297	17.2	17.24	82.5

The average results are closely alike for the different dates, and the individual records are so irregular as to indicate that these different dates of thinning had little or no effect on either the quantity or the quality of the crop.

As all the results are excellent, the tests would seem to show that the work of thinning can be extended over a period of at least two weeks without injury to the crop. As one person can thin an

acre of beets in about four days, it follows that a given planting can be thinned at the rate of one person to each three or four acres.

10. Variety Tests.

During the spring of 1898, the Station received from the U. S. Department of Agriculture, the seed of six varieties of sugar beets, with the request that they be given special tests. Two rows of each variety were sown, but, although the seed was sown at the rate of more than forty pounds of seed per acre, the stand was not so good as was gotten with the bulk of our beets. The seed of these six varieties was sown May 20, with a hand drill, in rows 18 inches apart, two rows of each kind, 177 feet long. The plants were thinned June 9 to nine inches apart, and the attempt was made to fill in the vacancies by transplanting, but nearly all of the transplanted beets died.

The first samples for testing were taken October 1, and the second samples October 22. The rest of the beets were dug October 26. The figures of analyses in the following table are the actual analytical results obtained on the beets three days after they were dug, with no allowance for drying out. During these three days, the beets had dried out about one-twenty-fifth of their weight. The beets were planted in the following order:

1. Zeringer, grown by Strandes.
2. Vilmorin's Improved, grown in Russia.
3. Kleinwanzlebener, grown by Vilmorin.
4. Pitschke's Elite.
5. Vilmorin's French, very rich.
6. Schreiber's Elite.

In the following table there has been added by way of comparison:

7. Average of eighteen rows of Kleinwanzlebener beets sown May 13 on the west side of the above varieties.

8. Average of fifteen rows of Kleinwanzlebener beets, sown May 27 on their east side. These last two were sown in rows 24 inches apart, and the intention was to thin them to six inches in the row.

Variety.	Per cent of full stand.	Average distance apart in row Inches.	Average weight per beet. Pounds.	Crop in tons per acre.
1	24	38	1.30	11.7
2	60	15	1.16	13.3
3	46	20	1.91	16.8
4	30	30	1.71	9.4
5	32	27	2.09	13.2
6	32	26	2.13	14.7
7	83	7	0.90	16.3
8	72	8	1.09	17.4

Variety.	Test of October 1.		Test of October 22.		Average.	
	Sugar in beet.	Purity.	Sugar in beet.	Purity.	Sugar in beet.	Purity.
1	14.73	73.4	15.44	76.9	15.08	76.6
2	16.48	84.9	16.96	79.0	16.72	81.9
3	14.82	78.9	15.68	77.7	15.25	78.3
4	17.20	87.1	17.20	76.3	17.20	81.7
5	15.49	80.4	14.73	77.6	15.11	79.0
6	16.15	80.3	15.06	76.7	15.60	78.5
7	15.54	74.3	17.80	78.8	16.67	76.5
8	16.50	79.9	16.87	77.4	16.68	78.6
Average	15.85	80.3	16.22	77.5	16.04	78.9

It will be noticed that the principal difference in the analyses of the two sets of samples is in the purity. The sugar in the beet improves about half a per cent, while the purity decreases nearly three per cent. The average analysis of these six varieties is almost exactly the same as of the Kleinwanzlebener beets we raised for our other tests on both sides of them.

Tests of several other varieties were made on the College farm in connection with the general test of European as compared with American grown seed. The results will be reported with the figures obtained on the same test throughout the state.

11. Number of Irrigations.

A plot of beets at the Rocky Ford substation was divided into three sections; the first received no irrigation during the season; the second was irrigated once, while the third was given four irrigations. The results are given in the following table:

Number of Irrigations.	Weight of crop in tons per acre.	Sugar in beet.	Purity.	Pure sugar per acre Pounds.
None	12.0	15.68	79.5	3763
One	12.4	17.58	85.1	4395
Four	11.9	15.53	78.7	3696

The results are somewhat different from those expected when the experiment was planned. They are to be explained by the fact that the unusually heavy rains of the season were almost enough to raise beets in that locality without any irrigation. The one irrigation gave the beets all the water they needed and the other three irrigations were a positive detriment.

In connection with the tests of seed from different sources, Mr. C. K. McHarg, of Pueblo, made for us some tests in regard to late irrigation.

All of the plot, containing three-fourths of an acre, was treated alike until the latter part of the season, then one-half received no further irrigation, while the other half was given two irrigations additional.

The crop was weighed for each variety separately and yielded the following results:

Variety.	Weight of crop from half not irrigated after August 20. Pounds.	Weight of crop from half irrigated twice after August 20. Pounds.
Original Kleinwanzlebener	1018	1133
Utah Kleinwanzlebener	1069	1125
Eddy Kleinwanzlebener	787	927
Elite Kleinwanzlebener	964	1111
Vilmorin	885	931
Mangold	694	1041
Total	5417	6268

In this case there was a gain of one-seventh in the weight of the crop by irrigations late in the season.

An average sample of the Original Kleinwanzlebener from the part receiving the extra irrigations tested 16.42 sugar in beet and 81.0 purity, while a sample from the other half tested 15.79 sugar and 81.7 purity. Here there was an advantage in both quantity and quality from the late irrigation.

AMERICAN-GROWN SUGAR BEET SEED COMPARED WITH THAT GROWN IN EUROPE.

An extensive series of tests was made of beet seed grown in the United States as compared with seed grown in Europe. Six varieties were used; one grown in France, one in Saxony, two in Germany, and two in the United States. The sources of the seed are as follows:

1. *Utah Kleinwanzlebener.*—This seed was grown at Lehi, Utah, by the Utah Sugar Company. The seed first used was the Original Kleinwanzlebener from Germany, and the seed tested this year was the second generation of American seed grown from the German seed.

2. *Original Kleinwanzlebener.*—Imported from Germany and sent to us by the Utah Sugar Company. Of course this is not the identical seed that was used as the ancestor of the Utah Kleinwanzlebener seed above mentioned, but it is from the same seed farm, of a crop a few years later and is presumably of about the same quality.

3. *Vilmorin.*—Sent us by the United States Department of Agriculture and imported by them from the original growers in France.

4. *Mangold.*—Grown by M. Knauer, Grœbers, Saxony, and imported for us by the agent, H. Cordes, LaGrande, Oregon.

5. *Eddy Kleinwanzlebener.*—This seed was grown at Eddy, New Mexico, during the season of 1897 from the beets of 1896 that were grown from seed obtained from Maison Carlier, Orchies, North France. It is, therefore, the first generation of American seed from the original French seed. This is the first crop of seed raised at Eddy.

6. *Elite Kleinwanzlebener.*—Imported from Germany by the United States Department of Agriculture.

Seed of these six varieties was sent to quite a number of persons in the various irrigated portions of Colorado, who had promised to take special pains in the test. Some of the tests were to be on a small scale with the richest of ground and the best of conditions. Another set of tests was to be on a larger scale under general farm conditions.

Great credit is due the experimenters for the large amount of labor and painstaking care that were bestowed on these tests. The first samples were taken the last week in September, being the Utah Kleinwanzlebener and the Original Kleinwanzlebener. Two weeks

later samples were requested of the Vilmorin and Mangold, and the next week the growers were asked to send samples of the other two varieties. About the first of November instructions were sent to harvest the crops and send samples of all six varieties.

Here are therefore two sets of samples, one set in three pairs and the other set from ripe crops in which the samples of the six varieties were taken at the same time and under the same conditions.

The earlier samples are all from the larger plots under field conditions. The later samples are given from the two plots separately.

UTAH KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Sept. 14	30	11.3	0.75	6.5	15.55	73.1
S. S. Abbott	Canfield	" 14	18	9.6	1.12	22.5	16.00	80.0
J. A. Davis	Berthoud	" 15	24	9.8	1.62	26.8	14.71	80.4
J. D. Payne	Grand Junction	" 15	18	9.1	3.25	26.6	9.09	64.6
C. K. McHarg	Pueblo	" 17	24	8.9	0.72	10.6	12.80	76.5
M. D. Parmenter	Lamar	" 15	18	6.7	1.10	28.0	14.71	78.3
Adam May	Debeque	" 17	18	8.4	1.12	23.5	15.22	82.3
F. M. Wright	Berthoud	" 19	18	25.7	1.00	7.0	12.80	70.3
E. K. Smith	Fort Lupton	" 22	18	.....	.....	.....	20.10	91.1
J. W. Dove	Alamosa	" 23	18	10.3	1.06	18.1	12.38	81.1
J. W. Douthitt	Montrose	Oct. 3	18	6.0	1.06	30 8	15.60	81.9
Average		Sept. 18	20	10.8	1.28	20.1	14.09	78.1

ORIGINAL KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth be-twe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Sept 14	30	11.1	0.62	5.4	14.82	69.8
S. S. Abbott	Canfield	" 14	18	9.6	1 00	18.2	14.09	78.5
J. A. Davis	Berthoud	" 15	24	10.3	2.00	25.4	13.89	79.5
J. D. Payne	Grand Junction	" 15	18	8.9	2.37	46.3	11 83	71.8
C. K. McHarg	Pueblo	" 17	24	11.1	0.60	7.2	16 74	83.0
M. D. Parmenter	Lamar	" 15	8	6.9	0.81	17.4	13.20	79.8
Adam May	Debeque	" 17	18	8.5	1.75	35.8	13.02	73.7
F. M. Wright	Be thoud	" 19	18	25 7	0.75	5.4	10.72	63.8
E. K. Smith	Fort Lupton	" 22	18	.....	.....	.....	15.04	76.1
J. W. Dove	Alamosa	" 23	18	9.4	0.75	14.3	11.81	77.6
J. W. Douthitt	Montrose	Oct. 3	18	7.2	1.25	30.7	16.13	85.0
Average		Sept 18	20	10.9	1.19	20.6	13.75	75.3

VILMORIN.

Name	Place.	Date of taking sample.	Wdth between rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
S. M. Scott	Fort Morgan	Oct. 25	30	13.6	0.95	7.2	16.44	87.7
S. S. Abbott	Canfield	" 13	18	9.2	1.45	27.2	16.44	......
J. A. Davis	Berthoud	" 14	24	15.6	1.42	11.4	15.48	81.0
J. D. Payne	Grand Junction	" 17	18	7.6	1.15	28.9	17.05	78.6
C. K McHarg	Pueblo	" 18	22	13.2	0.84	9.2	17.38	......
M. D. Parmenter	Lamar	" 13	18	12.4	1.54	21.7	16.67	88.6
Adam May	Debeque	" 18	18	10.0	1.40	24.5	16.87	72.5
F. M. Wright	Berthoud	" 25	18	24.0	1.37	11.5	16 15	81.3
E. K. Smith	Fort Lupton	" 12	18	8.6	0.64	13.1	17 42	......
J. W. Dove	Alamosa	" 17	18	8.0	0.87	20.0	11.80	78.5
J. W. Douthitt	Montrose	" 24	18	4.8	0.68	21.4	18.22	88.3
Average		Oct. 18	20	11.5	1.12	17.8	16.30	82.1

MANGOLD.

S. M. Scott	Fort Morgan	Oct. 25	30	9.8	1.39	14.6	13.06	73.8
S. S. Abbott	Canfield	" 13	18	9.2	1.52	29.0	16.39	78.0
J. A. Davis	Berthoud	" 14	24	15 2	1.57	13.5	12.58	74.2
J. D. Payne	Grand Junction	" 17	18	8.0	1.50	32.7	13.82	83.5
C. K. McHarg	Pueblo	" 18	22	15.2	1.02	10.0	17.42	......
M. D. Parmenter	Lamar	" 13	18	13.2	1.75	23.1	16.70	87.4
Adam May	Debeque	" 18	18	8.8	1.44	28.0	13.69	67.2
F. M. Wright	Berthoud	" 25	18	24.0	0.65	5.0	18.05	84.5
E. K. Smith	Fort Lupton	" 12	18	8.8	0.77	14.6	16.06	90.9
J. W Dove	Alamosa	" 17	18	7.2	1.12	27.2	10 86	77.8
J. W. Douthitt	Montrose	" 24	18	5.2	0 69	23.1	16.04	83.7
Average		Oct. 18	20	11 3	1.22	20.1	14.97	80.1

EDDY KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth betwe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre Tons.	Sugar in beet.	Purity.
S. S. Abbott..................	...... Canfield	Oct. 29	18	7.6	1.00	23.1	14.26	78.1
C. K. McHarg	.... Pueblo.......	Nov. 2	24	10.4	0.94	12.0	17.09	81.6
F. M. Wright	......Berthoud.. ...	Oct. 31	18	......	1.35	.....	13.03	73.7
J. W. Dove..................	......Alamosa	Nov. 1	18	7.2	0.62	24.5	12.70	83.3
Adam May	.... Debeque	" 14	18	......	1.30	......	16.39	85.8
J. D. Payne	..Grand Junction.	" 7	18	11.7	1.61	26.7	14.82	77.9
Average	....	Nov. 4	19	9.2	1.15	21.6	14.71	80.0

ELITE KLEINWANZLEBENER.

Name.	Place.	Date of taking sample.	Wdth betwe'n rows. Ins.	Average distance apart of beets in row. Ins.	Average wght of beets. Lbs.	Crop per acre Tons.	Sugar in beet.	Purity.
S. S. Abbott...........	...... Canfield	Oct 29	18	9.3	1.25	23.6	16.35	81.1
C. K. McHarg	.... Pueblo.......	Nov. 2	24	8.0	0.88	14.4	18.49	89.1
F. M. Wright................	......Berthoud......	Oct. 31	18	......	1.25	......	14.43	73.7
J. W. Dove..................	...... Alamosa	Nov. 1	18	8.0	1.12	24.5	9.37	69.7
Adam May....................	...... Debeque	" 14	18	......	1.30	......	16.39	82.3
J. D. Payne.................	...Grand Junction..	" 7	18	11.7	1.61	23.4	14.58	79.0
Average................	....	Nov. 4	19	9.2	1.23	21.5	14.93	79.1

AVERAGES.

Utah Kleinwanzlebener.............................	Sept. 18	20	10.8	1.28	20.1	14.09	78.1
Original Kleinwanzlebener............................	" 18	20	10.9	1.19	20.6	13.75	75.3
Vilmorin.................	Oct. 18	20	11 5	1.12	17.8	16.30	82.1
Mangold...	" 18	20	11.3	1.22	20.1	14.97	80.1
Eddy Kleinwanzlebener............................	Nov. 4	19	9.2	1.15	21.6	14.71	80.0
Elite Kleinwanzlebener............................	" 4	19	9.2	1.23	21 5	14.93	79.1

RIPE CROPS.

UTAH KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	9.4	1.05	19.4	16.26	83.8
M. D. Parmenter	Lamar	" 28	7.1	1.15	28.3	14.08	82.1
C. M. C. Woolman	Sterling	" 31	9.0	0.80	16.1	18.40	85.4
C. M. Rulison	Parachute	Nov. 12	5.3	1.36	44.6	16.91	81.9
C. K. McHarg	Pueblo	" 9	7.1	1.32	24 5	14.80	80.0
J. D. Payne	Grand Junction	" 12	9.2	5.10	105.5	8.88	64.6
Chas. Milne	La Jara	" 7	8.5	1.00	20 6	15.88	80.1
J. W. Douthitt	Montrose	" 8	6.7	1.18	31.2	12 63	74.5
Average		Nov. 4	7.6	1.12	26.4	15.57	81.0
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	9.6	1.11	20.1	16.00	87.8
C. M. Rulison	Parachute	Nov. 12	5.0	1.18	41.8	15.27	80.8
Substation	Focky Ford	Oct. 29	7.4	0 67	15.6	17.55	84.6
College Farm	Fort Collins	" 26	12.4	1.16	16.3	17.87	82.8
Average		Nov. 1	8.6	1.03	23.4	16.67	84.0

ORIGINAL KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	9.6	0.85	15.5	14 89	78.6
M. D. Parmenter	Lamar	" 28	9.6	2.18	39.9	12.46	76.6
C. M. C. Woolman	Sterling	" 31	9.0	0.87	18.0	16.57	76.9
C. M. Rulison	Parachute	Nov. 12	5.0	1.13	41.8	17.10	86.3
C. K. McHarg	Pueblo	" 9	8.9	1 59	23.4	14.13	79.6
J. D. Payne	Grand Junction	" 12	9.6	6.00	123.4	8.93	66.3
Chas. Milne	La Jara	" 7	8.0	0.97	21.2	15.75	79.8
J. W. Douthitt	Montrose	" 8	6.7	1.62	42.1	13.11	72.4
Average		Nov. 5	8.1	1.32	28.8	14.86	77.7
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	10.0	1.82	23.2	14.70	86.9
C. M. Rulison	Parachute	Nov. 12	5.3	1.22	39.6	16.39	81.7
Substation	Rocky Ford	Oct. 29	8.2	0.84	17.9	16.45	82.7
College Farm	Fort Collins	" 26	8.2	0.87	18.5	15 21	74.7
Average		Nov. 1	7.9	1.19	24.8	15.69	81.5

VILMORIN.

Name.	Place.	Date when crop was harvested	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.8	1.33	26.4	16 79	87.3
M. D. Parmenter	Lamar	" 28	7.0	1.13	28.3	14.38	76.1
C. M. C. Woolman	Sterling	" 31	9.0	0.94	18.0	15.31	78.6
C. M Rulison	Parachute	Nov. 12	5.2	1.10	37.2	15.31	83.6
C. K. McHarg	Pueblo	" 9	8.0	1.27	22.3	14.42	78.3
J. D. Payne	Grand Junction	" 12	9.0	4.46	90.2	9.65	67.9
Chas. Milne	La Jara	" 7	8.0	0.95	20.6	13.48	76.5
J. W. Douthitt	Montrose	" 8	6.7	1.06	27.7	13.80	74.2
Average		Nov. 4	7.5	1.11	25.8	14.78	79.2
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	16.0	1.82	14.4	14.95	84.8
C. M. Rulison	Parachute	Nov. 12	6.0	1.12	38.5	15.92	80.6
Substation	Rocky Ford	Oct. 29	7.0	0.50	12.5	18.00	89.2
College Farm	Fort Collins	" 26	10.9	0.92	14.7	17.15	78.5
Average		Nov. 1	10.0	1.09	20.0	16.50	83.3

MANGOLD.

Name.	Place.	Date when crop was harvested	Average distance apart of beets in row. Inches.	Average weight of beets Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.6	1.18	24.0	13.00	68.4
M. D. Parmenter	Lamar	" 28	6.7	1.32	34.5	13.42	80.6
C. M. C. Woolman	Sterling	" 31	9.0	0.78	15.5	14.43	74.9
C. M. Rulison	Parachute	Nov. 12	5.8	1.27	38.2	14.66	78.3
C. K. McHarg	Pueblo	" 9	8.3	1.28	20.0	13.71	78.3
J. D. Payne	Grand Junction	" 12	9.0	4.00	81.1	9.11	65.5
Chas. Milne	La Jara	" 7	8.0	1 06	23.0	14.32	74.8
J. W. Douthitt	Montrose	" 8	6.7	1.60	41.4	13.44	71.0
Average		Nov. 4	7.4	1.21	28.1	14.00	75.2
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	20.4	1.55	13.5	14.57	87.5
C. M. Rulison	Parachute	Nov. 12	5.0	1.18	42.3	15 88	82.7
Substation	Rocky Ford	Oct. 29	10.4	1.00	16.7	15.84	82.7
College Farm	Fort Collins	" 26	9.4	1.04	19.2	17.15	78.0
Average		Nov. 1	11.3	1.19	22.9	15.86	82.7

EDDY KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.0	1.04	22.0	......	......
M. D. Parmenter	Lamar	" 28	6.7	1.67	43.6	13.56	81.8
C. M. C. Woolman	Sterling	" 31	9.0	0.94	19.1	16.76	82.9
C. M. Rulison	Parachute	Nov. 12	5.6	1.12	34.4	16.04	84.8
C. K. McHarg	Pueblo	" 9	8.0	1.60	26.1	13.39	75.7
J. D. Payne	Grand Junction	" 12	9.2	5.00	98.5	10.36	69.5
Chas. Milne	La Jara	" 7	7.3	1.00	23.0	15.80	81.7
J. W. Douthitt	Montrose	" 8	6.7	1.22	31.0	12.70	70.8
Average		Nov. 4	7.3	1.25	27.0	14.71	79.4
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	10.8	0.95	15.5	14.22	81.8
C. M. Rulison	Parachute	Nov. 12	5.1	1.18	39.6	16.50	83.3
Substation	Rocky Ford	Oct. 29	8.4	0.70	14.4	16.82	87.5
College Farm	Fort Collins	" 26	11.1	1.06	16.5	15.80	78.1
Average		Nov. 1	8.6	0.97	21.5	15.83	82.7

ELITE KLEINWANZLEBENER.

Name.	Place.	Date when crop was harvested.	Average distance apart of beets in row. Inches.	Average weight of beets. Lbs.	Crop per acre. Tons.	Sugar in beet.	Purity.
Small Plot.							
S. S. Abbott	Canfield	Oct. 29	8.0	1.00	21.8	15.90	78.5
M. D. Parmenter	Lamar	" 28	6.7	1.60	40.4	15.75	84.0
C. M. C. Woolman	Sterling	" 31	9.0	0.92	19.2	17.23	83.4
C. M. Rulison	Parachute	Nov. 12	6.0	1.36	40.9	16.84	85.3
C. K. McHarg	Pueblo	" 9	7.7	1.50	25.6	15.38	80.0
J. D. Payne	Grand Junction	" 12	9.0	5.00	102.2	10.45	70 6
Chas. Milne	La Jara	" 7	8.0	1.11	24.2	15.50	85.7
J. W. Douthitt	Montrose	" 8	6.7	1 22	31.9	15.08	77.0
Average		Nov. 4	7.4	1.24	29.1	15.95	82.0
Large Plot.							
M. D. Parmenter	Lamar	Oct. 28	12.8	0.82	10.9	16.61	85.6
C. M. Rulison	Parachute	Nov. 12	4.9	1.14	40.7	15.42	84.2
Substation	Rocky Ford	Oct. 29	6.8	0.67	17.3	17.38	86.1
College Farm	Fort Collins	......	......	......	......	......	......
Average		Nov. 1	8.2	0.88	23.0	16.47	85.3

AVERAGES.

Variety.	Plot.	Crop per acre. Tons.	Sugar in beet.	Purity.
Utah Kleinwanzlebener..	Small	26.4	15.57	81.0
	Large	23.4	16.67	84.0
Original Kleinwanzlebener	Small	28.8	14.86	77.7
	Large	24.8	15.69	81.5
Vilmorin	Small	25.8	14.78	79.2
	Large	20.0	16.50	83.3
Mangold	Small	28.1	14.00	75.2
	Large	22.9	15.86	82.7
Eddy Kleinwanzlebener	Small	27.0	14.71	79.4
	Large	21.5	15.83	82.7
Elite Kleinwanzlebener	Small	29.1	15.95	82.0
	Large	23.0	16.47	85.3
Utah Kleinwanzlebener	Both.	24.9	16.12	82.5
Original Kleinwanzlebener	"	26.8	15.27	79.6
Vilmorin	"	22.9	15.64	81.2
Mangold	"	25.5	14.93	78.9
Eddy Kleinwanzlebener	"	24.2	15.27	81.0
Elite Kleinwanzlebener	"	26.0	16.21	83.6
Average	....	25.1	15.57	81.3

Variety.	Per cent of perfect stand. Weight.	Average weight of beets. Pounds.	Pure sugar per acre. Pounds.	Available sugar per acre. Pounds.
Utah Kleinwanzlebener	86	1.07	8060	6650
Original Kleinwanzlebener	87	1.25	8184	6514
Vilmorin	80	1.10	7163	5816
Mangold	75	1.20	7650	6036
Eddy Kleinwanzlebener	88	1.11	7390	5986
Elite Kleinwanzlebener	89	1.06	8429	7047
Average	84	1.13	7813	6341

A comparison of the results from the different kinds of seed shows, first of all, that they are all good seeds. An average of 25.1 tons of beets per acre testing 15.57 sugar and 81.3 purity is a very high yield. There is, however, considerable difference in the results from the different varieties. The Elite Kleinwanzlebener and the Vilmorin were sent us by the United States Department of Agriculture as the best beet seed that they could get. The Original Kleinwanzlebener was selected by the Utah Sugar company as in their judgment the best brand of seed on the market from which to raise their own seed. If we take the average of these three first-class seeds and compare it with the seed raised in Utah, the comparison is in favor of the Utah-grown seed in per cent of sugar and purity, while the crop per acre is equal. The Utah seed is, therefore, superior in pure sugar per acre and in available sugar per acre. The Utah seed is superior to the seed from which it is descended in sugar and purity, but a little inferior in quantity of crop.

The seed grown at Eddy does not give so good results as the Utah seed, but it equals the Vilmorin and is not far behind the Original Kleinwanzlebener. The germinating quality of the seeds is quite satisfactory. The four Kleinwanzlebener varieties give 87 per cent of stand, while the Vilmorin gives 80 per cent, and the Mangold 75 per cent.

In the light of these experiments there can be no doubt that sugar beet seed can be grown in the United States fully equal to the best of the imported seed.

The tables of the yield of the small plots include the figures from the field of Mr. J. D. Payne, of Grand Junction, but these figures are not used in making the averages, because they are so different from those of the other experimenters and so different from the average of Colorado results.

Mr. Payne planted his beets in a deep sandy loam, where the roots had unlimited room to grow downward. The soil below was full of water that was constantly being brought up to the roots by capillary action. The ground was also full of plant food. These beets, therefore, had the very best possible conditions and they improved their opportunities. The rows were 18 inches apart, and the beets thinned to 9 inches apart in the row. The stand was perfect and the growth enormous. Toward the latter part of the season the tops crowded so that the patch seemed one large beet. It was impossible to see any ground or to distinguish one beet from another. The beets averaged five pounds each and almost touched each other, making practically a solid row of beets.

As would be expected under these conditions, they never ripened and their quality is low. The figures of the crop are as follows:

Variety.	Crop per acre Tons.	Sugar in beet.	Purity.
Utah Kleinwanzlebener	105.5	8.88	64.6
Original Kleinwanzlebener	123.4	8.93	66.3
Vilmorin	90.2	9.65	67.9
Mangold	81.1	9.11	65.5
Eddy Kleinwanzlebener	98.5	10.36	69.5
Elite Kleinwanzlebener	102.2	10.45	70.6
Average	100.1	9.56	67.4

This is over 19,000 pounds of sugar per acre.

A SHIPMENT OF SUGAR BEETS TO GRAND ISLAND, NEBRASKA.

As will be given more in detail later, the Business Men's Association, of Loveland, Colorado, in connection with the Denver Chamber of Commerce, offered prizes for the best crops of sugar beets raised in the vicinity of Loveland. The officials of the Union Pacific, Denver and Gulf Railroad considered that this would be a good opportunity to test the beets of northern Colorado on a commercial scale. They obtained several hundred pounds of beet seed from the Oxnard Sugar Company, of Grand Island, Nebraska, and distributed this to the farmers of Loveland and vicinity, free of charge, on condition that the growers ship their beets to Grand Island. Instructions in regard to the methods of growing beets were sent to each one, by the College; the present writer visited a good many of the farms during the growing season and took notes on the crop and the care it had received, and as the season advanced he took samples for analysis at various times until it was evident that the crops were ripe enough to ship.

The changes of the crop in the process of ripening and the date when the crop was ready for harvesting, can be gathered from the following samples that were among those taken at Loveland :

Name.	Dated when sample was taken.	Sugar in beet.	Purity.
R. S. Cox	Sept. 22	12.45	73.4
" " "	Oct. 4	12.73	78.5
" " "	" 20	13.40	75.7
John Hahn	Sept. 22	14.21	76.6
" "	Oct. 4	14.54	83.7
" "	" 20	17.39	83.7
C. C. Smith	" 4	13.87	79.4
" " "	" 27	14.73	79.0
N. R. Faulkner	" 4	10.93	72.1
" " "	" 22	12.07	74.0
Alvin Shields	" 3	13.30	81.2
" "	" 29	15.96	86.8
J. S. Steele	" 4	13.06	76.6
" " "	" 29	15 68	82.9
Harvey Skinner	" 3	16.53	84 5
" "	" 27	17.38	85.3
I. W. Clapper	" 4	16 15	83.9
" " "	Nov. 1	18.53	80.4
D. Hershman	Oct. 18	12.11	77.5
" "	" 31	14.06	74.9
P. C. Benson	" 3	17.96	83.6
" " "	" 20	17.77	84.0
" " "	" 31	19.05	86.0

According to these figures, a factory could have found beets in proper condition for working the last week in September, and ten days later nearly half the crops were of excellent quality. All of the fields improved in quality during October, and some of the more backward were hardly ripe before the end of the month.

Harvesting for shipment to Grand Island began on October 28 and was completed November 2. Six carloads were shipped from Loveland, two from Fort Collins and one from Greeley. Each wagonload of beets was weighed when brought to the cars and samples of the beets taken for analysis. When the cars reached Grand Island they were weighed, the beets again analyzed, and also a sample was cleaned to ascertain how much dirt was attached to the beets.

Name.	Date of harvesting.	Sugar in beet.	Purity.
E. E. Bassett, No. 1	Oct. 28	17.48	85.3
Harvey Skinner, No. 1	" 28	15.06	79.4
" " No. 2	" 28	17.32	83.1
" " No. 3	" 28	18.15	87.4
H. L. Boyd, No 1	" 28	17.10	85.0
John Hokanson	" 28	17.39	84 2
J. M. Naylor	" 28	16.15	84.7
G. O. Whelchel, No. 1	" 28	15.63	86.8
John Derby	" 28	18.77	84.5
Pugh and Merry, No. 1	" 29	13.73	75.4
" " " No. 2	" 29	14.73	81.8
R. S. Cox, No. 1	" 29	13.82	78.2
" " No. 2	" 29	12.83	75.4
J. S. Steele	" 29	15.68	82.9
E. E. Bassett, No. 2	" 29	17.77	84.8
J. W. Flinn	" 29	16.63	83.4
H. L. Boyd, No. 2	" 29	16.91	84 5
J. R. Samuels	" 29	14.96	83.0
I. O. Holliwell, No. 1	" 29	16.58	78.1
" " No. 2	" 29	16.63	82.6
P. C. Benson, No. 1	" 29	19.33	87.9
" " No. 2	" 29	19.14	87.5
C. H. Brown	" 29	16.34	84.7
H. C. Caldwell, No. 1	" 29	12.97	73.7
W. H. Fairbrother	" 29	15.87	80.9
W. M. Pugh	" 29	14.20	78.1
J. J. Youtsey	" 29	18.00	87.2
G O. Whelchel, No. 2	" 29	18.53	86 6
W. S. Warner, No 1	" 29	17.53	80.1
Alfred Wild	" 31	15.25	80.7
F. G. Bartholf, No. 1	" 31	13.83	78.0
D. Hershman	" 31	14.06	74 9
E. F. Abernathy	" 31	15.34	78.2
W. S. Warner, No. 2	" 31	18.24	84.0
Alvin Shields, No. 1	" 31	14.39	77.8
" " No. 2	" 31	15.96	86.8
H. C. Caldwell, No. 2	" 31	16.15	82 0
John Hahn	" 31	15.01	75 5
P. C. Benson, No. 3	Nov. 2	19.05	86.0
F. G. Bartholf, No. 2	" 2	15.68	85.3
C. A. Anderson, No. 1	" 2	15.96	86.0
" " No. 2	" 2	15.44	87.7

The six cars of beets from Loveland were several days on the road, and of course dried out considerably. This would tend to lower the weight and raise the analysis, as is seen in the table below

Car.	Loveland weight.	Grand Island weight.	LOVELAND ANALYSIS.		GRAND ISLAND ANALYSIS.	
			Sugar in beet.	Purity.	Sugar in beet.	Purity.
U. P. 27599	31070	29600	16.00	84.8	17.1	84.8
O. R. & N. 6147	30850	30000	15.24	81.5	16.8	83.7
U. P. 40847	31870	30800	15.60	82.3	16.9	80.8
U. P. D. & G. 26964 ...	19000	17700	14 50	80.7	16.0	82.8
U. P. 66800	29460	25800	15.19	81.0	15.8	80.2
U. P. 41001	17590	16700	15.62	85.7	15.8	79.8
Average	26640	25100	15.36	82.7	16.4	82.0

The above shows a shrinkage, during the time of shipping, of 1,540 pounds per carload, or 6 per cent. In addition to this shrinkage, there was a still further deduction made for the "tare," or the dirt on the beets, and improper trimming. After making both these allowances, the record stands as follows :

Car.	Grand Island weight.	Per cent of tare.	Net weight.	Sugar in beet.	Purity.	Price for beets per ton.	Pure sugar per car.
U. P. 27599	29600	11.0	26344	17.1	84.8	$4.75	4505
O. R. & N. 6147	30000	7.0	27900	16.8	83.7	4.75	4687
U. P. 40847	30800	9.0	28028	16.9	80.8	4.75	4737
U. P. D. & G. 26964	17700	5.0	15930	16.0	82.8	4.50	2549
U P. 66800	25800	13.0	22446	15.8	80.2	4.50	3547
U. P. 41001	16700	10.0	15030	15.8	79.8	4.50	2375
Average	....	10.0	....	16.4	82.0	$4.62	....
Total	150600	....	135678	....	....	....	22400

No complete records were kept of yield per acre. There was some trouble about getting the cars for shipment, and owing to a shortage of cars there were so many beets that had been raised that were not shipped that it was impossible in several cases to tell the amount of land on which the part of the crop grew that was shipped. We have the records of about three-fourths of the beets, and the average of these is a trifle less than nineteen tons to the acre, gross weight, or, after taking out the tare, a little over seventeen tons net per acre. This gives about 5,300 pounds of pure sugar per acre, or about 300 pounds more sugar per acre for these

crops at Loveland raised under field conditions, than is found as the average of the whole state for the crops grown in competition for the sugar beet prizes.

This shipment of beets is one of the best ever made where the crop came from so many different farms, and shows conclusively that Colorado soil and climate are wonderfully adapted to the sugar beet.

In this connection, it seems proper to add the records of some shipments of sugar beets made in 1893 and 1894 from Grand Junction and vicinity to the sugar factory at Lehi, Utah :

Date of shipment.	*No. of cars.*	*Sugar in beet.*	*Purity.*
Nov. 15, 1893	1	15.7	84.0
" 20, "	1	16.2	84.0
" 20, "	1	15.0	84.0
1894	1	14.7	88.4
"	2	14.2	84.2
"	1	12.6	78.5
Average of seven cars		14.7	83.7

SUGAR BEETS AT GRAND JUNCTION.

The bulletins of the Agricultural College contain nearly all of the analyses that have ever been made of Colorado sugar beets. In order to make the record complete, it is deemed best to insert here two sets of analyses made in the years 1893 and 1894 of beets raised in the valleys of the Grand and the Gunnison.

The seed was furnished by the Utah Sugar company of Lehi, Utah, the samples of the beets were taken with the greatest care by men sent out for that special purpose, and the analyses were all made at the sugar factory at Lehi. The first table gives the results of the season of 1893:

Name.	Date planted.	First Sampling.			Second Sampling.		
		Date.	Sugar in beet.	Purity.	Date.	Sugar in beet.	Purity.
P. A. Rice	Apr. 20	Sept. 27	13.0	73.5	Oct. 25	13.6	73.6
Mr. Currie	" 20	" 27	12.2	73.5	" 25	12.7	76.1
A. A. Miller	" 20	" 19	10.2	72.3	" 25	14.1	81.3
Indian School	" 26	....	....	....	" 19	16.0	84.0
A. J. McCune	" 22	" 27	10.0	67.1	" 25	11.7	70.9
Ed. Bravier	" 22	" 27	13.4	76.1	" 19	15.7	85.0
Eugene Allison	" 28	....	....	....	" 25	16.5	81.3
Ovid Turnill	" 29	....	....	....	" 25	13.3	78.2
W. H. Benkitt	May 3	" 27	12.0	74.1	Nov. 4	14.0	78.3
W. D. Spencer	" 4	" 27	11.5	71.4	Oct. 31	13.8	78.5
N. Poffenberger	" 8	" 19	11.6	73.5	" 16	14.7	81.0
L. Johnson	" 8	" 19	9.5	67.5	" 25	12.6	84.0
W. F. Shewel	" 9	" 27	9.0	67.7	" 25	10.4	76.5
Joseph Smith	" 9	....	....	....	" 25	14.8	83.9
John Vaughn	" 10	" 27	12 4	72.1	....	....	....
M. S. Hildreth	" 11	....	....	....	" 31	12.8	77.2
J. C. Sullivan	" 12	....	....	....	" 31	12.3	72.2
Frank Leach	" 15	" 19	12.7	76.4	" 25	15.0	82.0
Geo. Davis	" 17	....	....	....	" 31	17.2	76.3
C. N. Cox	" 23	" 27	10.4	68.3	" 25	15.1	81.5
Smith Bros	" 15	....	....	....	" 25	16.1	83 7
Mr. Almes	" 15	....	....	....	" 31	12.5	78.8
Frank Rich	" 23	" 27	11.6	70.0	" 25	17.0	84.5
W. E. Renick	" 25	" 19	12.3	77.7	" 16	11.6	68.9
John Peugh	" 26	" 19	11.0	75.3	....	....	....
J. O'Keefe	" 30	" 27	11.0	78.8	....	....	....
J. A. Lawton	" 30	" 27	10.9	69 4	....	....	....

During the month from the latter part of September to the last of October the beets improved about two per cent in sugar and nearly ten per cent in purity. The shipments of carload lots were not made until late in November, and the beets of those that shipped had made by that time a still farther gain of one per cent in sugar.

The above crops represent all kinds of soil from one end of Grand valley to the other.

This was the first season that these farmers had raised sugar beets, and the general tendency was to give too much water and too little cultivation. Some of the fields had one cultivation, a smaller number were cultivated twice, and most of them had no cultivation

at all. In only a few cases was the thinning done with any degree of care.

In every case where the last analysis has shown a purity less than 80, the crop was irrigated from two to four times.

The work was repeated in 1894, and as many of the growers had had the benefit of the previous year's experience, the tests as a whole show an improvement. Only one set of samples was taken, and the results show that several of these were taken before the beets were ripe.

Sample Number.	Number of beets in sample.	Sugar in beet.	Purity.	Sample Number.	Number of beets in sample.	Sugar in beet.	Purity.
1	6	16.0	84.4	21	6	16.1	85.0
2	9	13.0	78.2	22	6	12.8	79.4
3	9	15.8	78.0	23	4	12.2	73.1
4	6	12.5	72.0	24	9	14.4	81.3
5	5	16.8	86.2	25	4	11.9	75.3
6	4	15.0	74.5	26	4	12.8	76.7
7	4	14.2	78.8	27	7	12.5	69.6
8	6	15.8	86.3	28	9	15.1	84.6
9	7	12.0	78.8	29	4	13.3	81.4
10	4	17.5	87.4	30	18	17.6	85.6
11	3	16.0	83.3	31	7	13.9	81.6
12	4	18.0	87.0	32	8	15.0	84.0
13	4	17.5	86.1	33	5	14.3	77.3
14	8	17.0	86.2	34	2	12.8	79.0
15	4	14.7	82.9	35	9	15.2	82.0
16	5	12.1	74.2	36	4	12.6	74.3
17	5	16.9	85.6	37	8	15.0	83.7
18	6	13.5	79.3	38	1	15.7	84.6
19	5	14.6	81.5	39	11	14.5	83.1
20	7	15.0	82.9				

Several of these samples deserve special attention. Numbers 2, 18 and 34 grew very large beets, from four to six pounds weight each, and had an enormous weight per acre, and yet, although these beets are not so rich as some of the others they are above the standard required by factories and would have brought a large return per acre. Numbers 27 and 28 came from the same field, the first from sandy soil and the other from heavy adobe soil. Number 39 is also from sandy soil, while number 30 is from new land and heavy adobe. In both cases the sandy soil gives poorer beets than

the heavy soil. The same has been noted in northeastern Colorado, where the heavy soil, though harder to work, gives a better quality of beet.

Numbers 1, 5, 10, and 17 had had previous experience in raising beets, and their crops averaged 16.8 sugar and 85.9 purity, showing that care and experience are all that are needed to raise the best of beets in the valley of the Grand.

SUGAR BEET PRIZES.

It was recognized in the spring of 1898, that the time had come when there should be a well organized effort to get the most exact information possible on the adaptation of the sugar beet to Colorado soil and climate. Nearly all the estimates of previous beet crops in Colorado have been based on the yield from a hundred square feet of ground. It was recognized by all that this was too small a plot for commercial estimates. It had been adopted because the beet growers disliked to spend the large amount of time and trouble necessary to make exact experiments on a large scale. It was seen that some substantial inducement must be offered before it could be expected that better results could be obtained than those of former years.

Acting on this idea, the Denver Chamber of Commerce offered $1,000 in cash prizes to those who grew the best crops of beets, these to be grown on a commercial scale, and each to cover 2,700 square feet of ground. The offer was conditioned on the appropriation of certain sums for the same purpose by the County Commissioners of each county. This was done by the County Commissioners of the following counties: Conejos, Costilla, Delta, Logan, Mesa, Otero and Weld. In Larimer county the money was subscribed by the business men of Loveland; in Fremont county by the Canon City Chamber of Commerce; while in Garfield county prizes were offered by the Denver and Rio Grande and by the Colorado Midland railroads.

The following instructions were sent to those who desired to compete for these prizes:

COLORADO AGRICULTURAL COLLEGE.

DIRECTIONS FOR HARVESTING THE CROP.

The plot of beets selected to compete for the prizes must contain, as nearly as possible, one-sixteenth of an acre, and must be all in one continuous piece. Call in a neighbor to witness harvesting and certify to the weights and measures.

Begin on one side and harvest every other row, *but no row harvested should be an outside row, i. e.*, if the plat selected is on the outside of the field, begin with the second row and harvest every other row.

Cut off the tops of the beets just at the base of the leaves, Shake the beets free from any loose dirt, and weigh the crop in this condition. This is the one referred to later as the "gross weight."

Throw the beets into a pile and roughly divide the pile in the middle, and again divide one of the halves in the middle, giving one-fourth of the original crop. Throw this fourth into a pile and treat it the same way, so that you have a fourth of a fourth, or about one-sixteenth of the crop. Weigh this lot and record it as the "gross weight of one-sixteenth of crop." Scrape these beets with a dull knife until they are free from dirt, fibrous roots and any stubs of leaves that may have been left on the crown. Weigh again and call this the "net weight of one-sixteenth of crop."

Count the number of beets in this last lot, and then select from it four to eight beets that together will weigh about eight pounds, and will be representative of the crop, *i. e.*, select big, medium and little, good shaped and bad, so as to get a fair sample of the lot. Weigh these beets together *very carefully*, and record this as "weight of sample for analysis."

Wrap each of the beets separately in paper and then do them up in two packages, not to exceed four pounds in each package, sew each package up securely in cloth and attach the mailing tag, which will enable the package to be sent postage free.

The harvesting, weighing and preparing the sample for analysis should all be done on the same day, and as quickly as possible to prevent drying out.

Three blanks are sent you; one to be filled out and enclosed in each package, and the other to be kept by you for your own information.

Mail the sample for analysis as soon as possible after it is ready. The receipt of the sample for analysis will be acknowledged by return mail.

Do not harvest the rest of the plot until you receive word that your sample and records are satisfactory. By this means it may be possible to correct mistakes, if any have accidently been made.

It will be seen from the instructions, that it was desired that the crops be harvested and sampled between October 15 and November 1. In the case of Logan county, the crops were harvested the last week in September, so that they could be exhibited at the county fair. The crops were not then ripe and the results are much poorer, both in quantity and quality, than would have been obtained had the beets remained in the ground a month longer. At the request of the present writer, two of these fields were but partly harvested, and the rest of the beets were pulled the latter part of October, when the beets in the other counties were being harvested. In each case the beets tested in sugar more than three per cent higher than during September.

It was desired that the contest be put as nearly as possible on a commercial basis, *i. e.*, the prizes be awarded to the crops in the order of their real value for sugar making purposes. It was necessary then, to take into account three things: The weight of the

crop, the amount of sugar in the crop, and the amount of sugar that could be gotten out in the factory. These items are given in the accompanying tables. The column headed "Gross weight of trimmed beets per acre," gives the weight of the beets in the same condition as they would ordinarily be brought to a factory, *i. e.*, with the tops cut off, but no attempt made to remove the dirt that naturally sticks to the beet. At a factory, a sample of the beets, usually about half a bushel, is taken and cleaned and the calculation made as to how much dirt there is in the whole load.

The column headed "Sugar in the beet," represents the character of the beet at the time it was analyzed. On the average, this was about three days after harvesting. During this time, of course, the beets had been drying out, which would tend to raise the per cent of sugar in the sample. The first two columns, therefore, represent the gross weight of beets and dirt together and the analysis of a partly dried sample, in both cases making the crops apparently better than they were. To offset this, the column headed, "Pure sugar per acre," is obtained by multiplying the other two together and deducting one-fifth for tare and drying out. It is probable that this is a larger shrinkage than would have been made had these crops been sent to a sugar factory, but it is deemed best to make sufficient reduction so there could be no possible appearance of an attempt to exaggerate Colorado's sugar beet crops. The figures. even after the 20 per cent reduction, show magnificent crops, and still more so that we can look at them as a slight underestimate.

The column headed "Purity," is the measure of the factory value of the sugar that is in the beet. If a lot of beets test 80 purity, it means that for every 80 pounds of pure sugar they contain, they also have 20 pounds of impurities that are not sugar. These impurities prevent the factory from saving all the pure sugar, and the greater the amount of impurity the greater the amount of pure sugar that will be lost in the process of manufacture. The "pure sugar per acre," multiplied by the "purity" will give the "available sugar per acre," or the approximate amount of sugar that would have been produced from the crops in an ordinary factory. It is considered that this measures the true sugar value of the crop, and it is on the figures of this column that the order of excellence of the various crops is based.

In the table of averages by counties, another column is introduced headed "Factory value per acre." It is obtained by deducting ten per cent tare from the gross weight of the crop and multiplying the remainder by the price paid during 1898 by factories where the price is varied according to the quality of the beets. The prices used are:

$3.75 per ton for beets testing less than 14.4 sugar and less than 78 purity.

$4.00 per ton for the same sugar and more than 78 purity.
$4.25 per ton for tests from 14.5 to 15.4 sugar.
$4.50 " " " " " 15.5 to 16.4 "
$4.75 " " " " of 16.5 sugar or higher.

CONEJOS COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Chas. Milne, La Jara	Nov. 7	28.16	17.65	79.8	7952	6436
W. M. Martin, Alamosa	Oct. 29	24.57	16.96	86.8	6684	5802
W. A. Braiden, La Jara	" 10	20.05	11.45	72.2	3673	2803
D. E. Newcomb, La Jara	" 12	12.80	15.65	80.1	3205	2563
S. J. Parish, Alamosa	" 16	12.06	16.64	80.5	3174	2554
J. L. Rutledge, La Jara	" 15	....	18.91	84.4	....	....
J. W. Dove, Alamosa	....	....	13.19	78.0	....	....
Mrs. N. A. Broyles, Antonito	" 15	....	11.97	70.9	....	....
Average	Oct. 21	19.53	15.67	80.0	4689	3741

COSTILLA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
G. W. Shaw, Alamosa	Oct. 22	12.29	15.30	86.6	3008	2605
A. McKinnon, Alamosa	" 18	7.26	12.54	83.8	1457	1213
Peter Legard, Alamosa	" 20	....	15.58	....	....	....
N. E. Morgan, Hooper	Nov. 7	....	20.43	83.2	....	....
R. W. Maddux, Mosca	Oct. 15	....	12.40	83.8	....	....
Wm. Douglas, Mosca	" 18	22.60	....	....	....	....
Average	Oct. 22	14.05	15.42	84.3	3093	2607

DELTA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
G. H. Hammond, Hotchkiss	Oct. 22	38.51	17.34	77.4	10962	8485
Martin Cade, Delta	" 17	20.57	15.91	89.5	5236	4686
G. W. Umbrell, Delta	" 31	21.78	14.68	80.9	5116	4139
I. S. Hewitt, Delta	" 19	19.96	12.87	71.0	4118	2924
J. M. Trew, Delta	" 19	10.87	13.40	76.5	2331	1783
Charles A. Barnes, Delta	" 28	....	15.44	83.9	....	....
Average	Oct. 23	22.54	14.74	80.0	5301	4241

FREMONT COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure Sugar per acre. Lbs.	Available sugar per acre. Lbs.
B. F. Rockafellow, Canon City	Oct. 21	30.05	18.05	86.8	8678	7533
William Curtis, Canon City	" 29	29.18	16.63	86.9	7766	6748
L. K. Mortimer, Canon City	Nov. 2	26.35	17.96	83.5	7589	6337
Charles Kaess, Cotopaxi	Oct. 24	29.40	16.63	79.6	7822	6226
G. E. Murray, Howard	" 15	29.80	15.33	84.3	7310	6162
W. A. Dumm, Canon City	" 28	21.33	18.05	82.0	6160	5051
J. M. Murray, Howard	" 15	29.52	13.63	79.4	6444	5117
John Ripley, Canon City	" 27	21.90	16.96	80.3	5942	4772
H. T. Gravestock, Canon City	" 20	14.50	16.48	90.7	3831	3475
E. S. Armstrong, Hillside	" 12	16.13	15.68	77.7	4046	3116
C. H. Gravestock, Canon City	" 28	8.45	19.00	84.8	2569	2178
E. V. Kimmel, Canon City	" 20	....	18.05	93.5	....	....
Phil Sheriden, Canon City	" 18	....	19.10	81.3	....	....
B. F. Rockafellow, Canon City	" 29	....	18.24	81.8	....	....
J. E. Brown, Canon City	....	....	14.42	81.3	....	....
A. C. Haggart, Canon City	" 20	....	12.06	67.7	....	....
Average	Oct. 23	23.36	16.87	84.1	6226	5236

GARFIELD COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure Sugar per acre. Lbs.	Available sugar per acre. Lbs.
C. H. Harris, Catherin	Oct. 29	37.98	17.20	80.1	10458	8397
D. G. Edgerton, Carbondale	" 18	14.91	17.34	91.8	4113	3776
Jesse Kerlee, Parachute	" 19	10.77	15.68	88.0	2702	2378
Charles H. Miller, Antlers	" 17	12.17	14.25	79.4	2774	2203
W. C. Parker, New Castle	....	....	17.39	82.9	....	....
C. M. Rulison, Parachute	....	....	15.89	82.2	....	....
Harry Brenton, Rifle	....	....	15.91	83.6	....	....
F. W. Mallory, New Castle	" 21	....	15.96	76.1	....	....
E. E. Westhafer, Satank	" 18	....	15.01	86.7	....	....
F. M. Peebles, Satank	....	....	16.29	78.8	....	....
Average	Oct. 21	18.96	16.12	84.8	4901	4153

LARIMER COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
J. M. Naylor, Loveland	Oct. 23	36.26	16.53	79.3	9590	7589
I. W. Clapper, "	Nov. 1	31.60	18.53	80.4	9369	7533
C. C. Smith, "	Oct. 27	33.01	14.73	79.0	7781	6147
F. G. Bartholf, "	" 31	28.72	15.68	85.3	7205	6142
Alfred Wild, "	" 27	31.50	15.25	80.7	7606	6138
Alvin Shields, "	" 29	27.47	17.43	79.7	7490	5970
Harvey Skinner, "	" 27	24.80	17.38	85.3	6896	5882
R. O. Joslyn, "	" 27	14.10	18.05	84.8	4072	3453
R. S. Cox, "	" 27	21.05	13.40	75.7	4513	3416
P. C. Benson, "	" 31	10.72	19.05	86.0	3267	2810
N. R. Faulkner, "	" 22	19.35	12.07	74.0	3456	2765
Average	Oct. 28	25.32	15.69	80.9	6356	5091

LOGAN COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Fred Bernhard, Sterling	Sept. 26	34.15	13.40	72.7	7322	5323
W. C. Propst, Merino	" 25	24.50	14.72	76.2	5771	4397
A. F. Krause, Sterling	" 27	21.50	14.50	83.7	4988	4175
J. H. King, Sterling	" 27	18.10	13.30	79.1	3852	3047
C. D. Brownell, Iliff	" 26	14.60	14.72	80.0	3438	2750
C. M. C. Woolman, Sterling	" 27	12.50	14.30	72.4	2860	2071
C. E. Harter, "	" 27	9.50	15.33	78.8	2331	1837
T. A. Whiteley, "	" 26	7.65	14.15	71.5	1730	1239
James Weir, "	" 26	....	14.49	78.2	....	....
M. V. Propst, "	" 26	....	14.25	78.8	....	....
John Landrum, "	Oct. 1	....	14.10	79.2	....	....
R. C. Perkins, "	Sept. 27	....	13.30	79.1	....	....
H. C. Hatch, "	" 26	....	12.63	73.3	....	....
Average	Sept. 27	17.8	14.09	77.3	4013	3102

MESA COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Fred Burmeister, Grand Junction	Oct. 1	36.0	17.10	86.3	9850	8491
J. D. Payne, Grand Jnnction	Nov. 23	29.3	16.57	76.0	7768	5904
Adam May, Debeque	" 14	22.0	16.41	77.3	5776	4465
W. K. Sterling, Collbran	Oct. 26	21.0	14.30	88.2	4805	4234
Joseph Dietz, Fruita	" 29	27.0	13.54	71 6	5850	4183
J. P. Veach, Fruita	" 29	11.2	19.81	85.4	3878	3313
E. B. Bonnel, Grand Junction	" 25	23.2	11.40	68.2	4241	2932
C. V. Wasson, Grand Junction	Nov. 5	11.6	16.15	75.8	3019	2289
G. N. Patterick, Grand Junction	" 2	16.5	11.88	72.7	3142	2284
S. M. Cox, Fruita	Oct. 29	....	15.16	77.0	....	....
H. S. Groves, Fruita	" 29	....	14.16	78.4	....	....
Lee D. Wilson, Grand Junction	Nov. 21	11.7	....	....	....	....
Average	Nov. 2	20.9	15.22	77.9	5114	3984

OTERO COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
J. W. Ruble, Rocky Ford	Oct. 25	31.40	18.19	86.2	9138	7877
J. P. Pollock, La Junta	Nov. 7	33.52	18.01	77.7	9652	7500
B. F. Wyckoff, Rocky Ford	Oct. 25	23.21	14.16	78.3	5259	4108
Albert Conner, Rocky Ford	" 27	27.70	10.83	72.8	4800	3494
C. S. McKinley, Fowler	" 20	13.27	16.06	84.7	3411	2889
Fred Janrow, Fowler	" 29	18.17	13.30	73.6	3906	2875
Richard Mason, Higbee	" 20	10.70	15.20	78.3	2603	2048
C. S. Heath, La Junta	" 26	....	15.39	76.8	....	....
C. W. Ruckman, La Junta	" 20	....	14.96	83.3	....	....
M. A. Gordon, La Junta	" 29	....	15.34	76.8	....	....
Marten Sorensen, Fowler	" 17	....	15.39	73.4	....	....
Average	Oct. 26	22.59	15.14	79.8	5474	4379

WELD COUNTY.

Name and Place.	Date of harvesting the crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.
Leonard Burch, New Windsor	Oct. 25	17.17	17.10	83.5	4699	3924
Newton Clegg, Greeley	" 25	12.20	16.25	78.1	3172	2477
Martin Nelson, Greeley	" 18	12.58	15.68	74 2	3154	2340
Fritz Niemeyer, Evans	" 26	....	14 54	82.4	....	....
C. F. Mason, Greeley	" 13	....	14.44	81.2	....	....
Average	Oct. 23	13.98	15.89	79.8	3562	2850

AVERAGE RESULTS BY COUNTIES.

County.	Date of harvesting of crop.	Gross weight of trim'ed beets per acre. Tons.	Sugar in beet.	Purity.	Pure sugar per acre. Lbs.	Available sugar per acre. Lbs.	Factory value per acre.
Conejos	Oct. 21	19.53	15.67	80.0	46.89	3741	$ 79.11
Costilla	" 20	14.05	15.42	84.3	30.93	2607	56.92
Delta	" 23	22.54	14.74	80.0	53.01	4241	86 23
Fremont	" 23	23.36	16.87	84.1	6226	5236	99.75
Garfield	" 21	18.96	16.12	84.8	4901	4155	76.98
Larimer	" 28	25.32	15.52	80.2	6278	5023	102.56
Logan	Sept. 27	17.80	14.09	77.3	4013	3102	64.00
Mesa	Nov. 2	20.90	15.22	77.9	5114	3984	79.90
Otero	Oct. 26	22.59	15.14	79.8	5474	4374	86.40
Weld	Oct. 23	13.98	15.89	79.8	3562	2850	56.70
Average	Oct. 22	19.90	15.47	80.8	4950	4000	$ 76.07

In considering the foregoing tables, one is struck at once with the high average excellence of the sugar beets of Colorado as regards both quantity and quality. In the districts of the United States, where beets are raised for factories, 12 per cent of sugar and 78 purity are considered standards, and one who has raised ten to thirteen tons of beets to the acre is thought to have done well. A fair estimate of the cost of raising sugar beets is $30 per acre, while the above table gives $76.07 as the average factory value for the whole state. The difference of $46.07 profit per acre will compare well with any other kind of farming practiced in Colorado, not even excepting the famed cantaloupes of the Arkansas valley, the orchards of the western slope, or the lambs of the northern feeding districts.

In concluding this portion of the subject, it is fitting that grateful appreciation should be expressed of the aid that the Denver Chamber of Commerce has given in this work. The above tables present the largest amount of the most reliable reports that have ever been collected concerning Colorado sugar beets, and their collection was made possible, only through the generosity and public spirit shown in offering the sugar beet prizes.

The State Agricultural College.

THE AGRICULTURAL EXPERIMENT STATION.

BULLETIN NO. 52.

I. Pasturing Sheep on Alfalfa.

II. Raising Early Lambs.

Approved by the Station Council,
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

APRIL, 1899.

Bulletins will be sent to all residents of Colorado, interested in any branch of Agriculture, free of charge. Non-residents, upon application, can secure copies not needed for distribution within the State. The editors of newspapers to whom the Station pubications are sent are respectfully requested to make mention of the same in their columns. Address all communications to the

DIRECTOR OF THE EXPERIMENT STATION,
Fort Collins, Colorado.

EXPRESS, FORT COLLINS

THE AGRICULTURAL EXPERIMENT STATION.

FORT COLLINS, COLORADO.

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I. PASTURING SHEEP ON ALFALFA.

BY W. W. COOKE.

The high price of sheep and lambs during the years since 1896 has turned the attention of sheep feeders to the question of raising the lambs they feed, in place of depending on the ranges of the south and west. The summer feed for the sheep, where there is no range, is the most difficult problem attending the raising of sheep on the ranches. It has been generally recognized that if it was as safe to pasture sheep on alfalfa as it is to let horses run on the same feed, there would be but little difficulty in raising lambs on any of the farms of the irrigated districts of Colorado. Many have tried pasturing sheep and lambs on alfalfa, but so many sheep have been lost by bloat that most herders have dropped the practice and others have been deterred from attempting it.

The high price of sheep has again awakened interest in the subject and led to the following experiments and investigation:

In the early fall of 1897 we bought eleven ewes for the purpose of making a double test, *i. e.*, the raising of early lambs and the pasturing of these lambs and the ewes on alfalfa during the summer of 1898. The ewes were mixed Shropshire and Merino, weighing about ninety pounds apiece. They were old ewes that had still fairly good teeth, but were so old that it was expected that the 1898 lamb would be the last one raised. They reached the college farm October 29, 1897, and were bred as soon as possible to the fine registered Shropshire ram Bennett's Prince, No. 87674, that stands at the head of the college flock. The eleven ewes dropped eleven lambs, most of them within a week after March 4, 1898. Through the winter the ewes were fed alfalfa hay. They received a small amount of ensilage during part of the winter, but in figuring on the finan-

cial side of the transaction this has been counted at its equivalent feeding value in alfalfa. As soon as the lambs were dropped, some grain was added to the feed and both ewes and lambs were turned on to alfalfa April 20. At this time the young alfalfa was barely showing green and the feeding of alfalfa hay and grain was continued until the green alfalfa was about four inches high. At first they were given the run of a field containing about three-fourths of an acre of fairly good alfalfa and half an acre of poor alfalfa, which was considered equal to an acre of medium alfalfa. The season proved very dry and as the field could not be irrigated the alfalfa did not make enough growth to supply them all the food they needed. About the middle of June they were given access to a second field of two acres of alfalfa. Even with the aid of several pigs they could not keep up with both fields, and one cutting of the alfalfa was made for hay. It was estimated that the total green alfalfa eaten by the sheep and lambs was about equivalent to an acre and a half of good alfalfa that would cut from three to four tons of alfalfa hay to the acre during the whole season. The sheep were shut up at night in a small corral to keep them away from dogs and coyotes. During all the summer they were fed half a pound of bran per day per head, of both sheep and lambs. On June 12 one of the ewes died of bloat and on June 20 one of the lambs followed its example, leaving us ten ewes and ten lambs.

The ewes were sheared April 29, yielding 54 pounds of wool from the ten ewes, showing that they were rather light fleeced sheep.

The experiment closed September 6, at which time the ewes weighed an average of 103 pounds and the lambs an average of 94 pounds. We sold the ewes for $3.50 per head. If we could have had the lambs in Chicago at that time they would have sold for $6.00 per head, but we had too few to make a shipment and so they are counted at their value in the Colorado market, *i. e.*, $4.00 per head. Thus the whole experiment was closed up in a few days over ten months.

SUMMARY.—Expenses.

To 11 ewes @ $2.50	$27.50
Service of ram	2.50
Alfalfa hay, 5 pounds per day per head for 180 days, 5 tons @ $4.00 per ton.	20.00
1600 pounds of grain @ $11.00 per ton...	8.80
Total expenses..................	$58.80

Receipts.

54 pounds wool, less cost of shearing....	$ 7.00
10 ewes @ $3.50......................	35.00
10 lambs @ $4.00......................	40.00
Total receipts..................	$82.00
	58.80
Net return	$23.20

The above amount, $23.20, represents the return for the labor of caring for the sheep and for the acre and a half of alfalfa pasture. If the estimate is made that it costs thirty cents per head to look after sheep through the winter, which is a close approximation where many sheep are kept, there remain $20.00 as the return for the alfalfa from one and a half acres of ground. This is more than four dollars a ton for alfalfa in the field, with the sheep doing all the haying, or more than five dollars a ton for the hay in the stack. These results also include the estimating the hay eaten during the winter at four dollars per ton.

It should be remembered that these are the financial results, notwithstanding a nine per cent. loss from bloat on both the ewes and the lambs. While it may be that less than nine per cent. loss cannot be safely estimated on the ewes, it is seldom that a lamb bloats on alfalfa pasture and it would be safe to expect no loss from this source.

It is a fair question whether we received an extra growth and corresponding return for the grain fed during the summer. This cannot be told, as we had no check lot not receiving grain. Other sheepmen in Colorado who pasture sheep on alfalfa are not in the habit of feeding grain after the alfalfa gets in good growth. But on the other hand they do not get so large a growth on their lambs as we did. The grain fed through the summer amounted to 700 pounds, or $3.85 and it is probable, though not certain, that the lambs grew the 10 pounds each of live weight necessary to pay for the grain.

The only other person in the vicinity of Fort Collins who pastured sheep on alfalfa during the season of 1898 is C. W. Trimble. He pastured 40 ewes and 40 lambs on two acres of good alfalfa. They remained on the alfalfa day and night, rain and shine, all the season, except three times of four or five days each when the land was irrigated, then they were taken off and fed alfalfa hay. They had forty pounds of corn chop per day, *i.e.*, one pound a day for a ewe

and her lamb. None were lost by bloat of either ewes or lambs. After the third crop of alfalfa was cut the ewes and lambs were turned on the stubble to eat the fourth crop. The lambs were taken up in the latter part of September to feed for market. They weighed then about 65 pounds per head. The ewes remained in the fields until late. The same ewes are being kept for a repetition of the test in 1899.

PASTURING ALFALFA IN THE ARKANSAS VALLEY.

More attempts have been made in the Arkansas valley to pasture sheep on alfalfa than in any other part of Colorado. Some years when the feed on the range has been poor quite a large number of sheep have been pastured part of the season on alfalfa, but during the summer of 1898, the range grass was very abundant and nearly everybody turned the sheep and lambs on the range. The center of the sheep industry in the Arkansas valley is the counties of Otero, Bent and Prowers. Statements were obtained from those who had had the most experience in pasturing sheep on alfalfa and they are given herewith as showing what diverse results have been obtained and how various the opinions now held by those most familiar with the subject.

W. E. DOYLE, Pueblo.

We tried raising lambs on alfalfa pasture during the spring of 1898 and got along very well for the first two or three weeks while the pasture was short. But just as soon as the alfalfa got to growing faster than the sheep could eat it down close, they began to bloat, and before I gave it up I had lost about sixty head of fine Shropshire ewes and several lambs. I tried every precaution I knew of, such as not turning out until late in the morning, having them well filled with hay and grain, but it seemed to make no difference. Some days there would be no losses; then would come a day when a dozen would die after they had been grazing four or five hours.

My opinion is that if one had a dog and coyote proof fence around the pasture and kept the sheep on night and day and kept the alfalfa picked down close until they got accustomed to it, the loss would not be so large.

However, from what I have been able to learn from

those who have had more experience than myself, they suffer from 15 to 25 per cent. loss, which at the present high price of ewes is rather expensive.

WM. and H. G. GREENE, Olney.

Our late lambs began to come about the tenth of April, and both in 1897 and in 1898 we lambed them on alfalfa. We put the ewes on the alfalfa before it started and kept them there until we were through lambing. We yarded them at night. Until the alfalfa got well grown we fed them hay.. When feed began to get plenty, they would bloat more or less, but we never lost a sheep.

The first season after the lambs were a few days old we tried returning the ewes to the alfalfa. But we could not make it work. The ewes would bloat and die, if they were only on for a short time, even fifteen to twenty minutes, Last year we did not try to return the ewes to the alfalfa after they came in, but took them to the prairie which was good feed. By running the dropping band on alfalfa, the ewes have plenty of milk and are in good condition. We expect to run the dropping band in 1899 the same way. We have fine lambs and expect to get nearly one hundred per cent. increase. We have tried other ways of running sheep on alfalfa but cannot make a success of it.

D. C. ROBERTS, Ordway.

My experience in pasturing alfalfa with sheep is on rather a small scale. Among my sheep that I was fattening during the spring of 1898, were eight ewes that dropped lambs in April—fifteen lambs from the eight ewes—while on dry feed in the corral. When I sold my sheep in May, these ewes and lambs were turned loose in the alfalfa fields, twenty-three head in all. They roamed over the farm at their own will, seldom coming near the barn. In September I put them in the corral again and found there were twenty-three head still. On September 10, several of the larger lambs weighed 80 to 90 pounds. They were on the green alfalfa through wet and dry and apparently never bloated.

S. McCARTA, Manzanola.

In October 1896, I bought my first bunch of sheep. I

got them home about two o'clock in the afternoon, turned them into an alfalfa field, went on to the house and paid no attention to them except to look from the house and see if they were still in the field. About sundown I turned them into the corral. I thought they looked full, but never thought of bloat, as the party from whom I bought them assured me there was no danger in pasturing on alfalfa. The next morning I turned them into the same field, and continued this practice as long as there was anything in the field to eat, in fact nearly all winter. The alfalfa was nearly a foot high when I turned them in and they were very hungry, for I had driven them thirty miles during the day and a half, and they had had little to eat or drink. This was my first experience in pasturing sheep on alfalfa and I never lost a single one. By the fall of 1897 I had received the advice from all the know-alls in the sheep business. I was warned never to let the sheep on to the alfalfa unless they were well filled up with feed and water, also especially never to turn sheep on alfalfa early in the morning.

I adhered to both of these rules until I lost about forty-five ewes. The last loss was sixteen in less time than it takes to write it. They came off of a hill pasture where they had been all day. This was at four o'clock in the afternoon. Before half-past four they were tumbling in every direction.

The next morning early I opened the gate from the corral and let them into the alfalfa field. Then I told my man not to go near them and I went away for the day, and at night they were all right with not a single loss. After that I continued to shut them up late at night and turn them out early and lost no more from that bunch.

A few weeks later I bought another bunch of 600 ewes. I filled them up well on hay and corn for about a week. Then about the middle of one afternoon I turned them into the alfalfa. In half an hour I had lost nine head. The next morning I turned them out at daylight and lost no more. In all these cases there was plenty of water in all the fields.

In the spring of 1898 I had about 900 ewes to lamb. Five hundred of them were in one bunch in a corral at one corner of a fifty acre alfalfa field. Early in the morning we opened the corral gate and filled the racks with hay so that the sheep could roam over the field or stay and eat hay if they preferred. This was begun before the alfalfa started. It was kept up until the middle of May by which time the alfalfa was a foot high. Then as we needed the alfalfa for

hay we turned the sheep on the range. In all this time we lost only one sheep and it is not sure that this one died of bloat. We were very careful not to drive or bother this bunch of sheep. When they had all gathered in the corral at night the gate was closed and opened again very early in the morning.

The other 400 ewes had no alfalfa field so convenient to their night corral and they had to be both driven and herded. We had almost daily losses with this bunch until finally we made some new fencing that allowed them to roam without herding and after that our losses ceased.

In the light of these three season's experience, it seems to me that if a person wants to make a success of pasturing alfalfa and is so situated that he must corral the sheep at night, then this corral should be in the field where there will be no need ever to drive the sheep or worry them.

In the fall of 1898 I took sheep off the cars and turned them at once into an alfalfa field that had been cut but once during the season and where the alfalfa was so high the sheep could hardly be seen. Yet there were no losses.

In regard to the profit of thus pasturing alfalfa; I have made a little money at it and I believe there is money in it for anyone who has sufficient land and capital so that he can arrange matters properly.

W. B. BALDWIN, Fowler.

We have had considerable experience in pasturing sheep on alfalfa. At first we lost quite a number, but finally found that the loss would be largely reduced if we left the sheep on the alfalfa day and night and kept the alfalfa large. We also found it best to have the sheep's stomach empty when put on alfalfa and then not take them out even if they do bloat. Our theory is that if the stomach is empty there will be room for a large amount of gas if they do bloat, and as soon as they begin bloating they will stop eating and but few will die. This theory is altogether different from the general opinion, but it is all right. Sheep must not change pasture. They must stay on the same pasture all summer if you wish to have success. Good alfalfa will keep about eight ewes and their lambs per acre. It should be irrigated often so as to keep the alfalfa from getting dry. If the alfalfa should get dry and you have to change the sheep to another field, you may expect losses.

Shropshires are the hardiest sheep I have had on pasture or on range.

Lambs do not bloat on alfalfa pasture until they are old enough to wean.

Alfalfa is certainly the best thing to lamb on for spring lambs. We are now (January 1899) having our first experience in lambing ewes in the winter. We have 1100 ewes and so far have saved about ninety-five per cent. of the lambs.

W. H. NEY, Fowler.

The best way to guard against bloat in pasturing sheep on alfalfa is to feed the sheep well on any dry feed just before turning them on the alfalfa and turn them in while full and leave them there night and day. By this method the losses will be light and success assured. Alfalfa pasture has great fattening qualities and early lambs having the run of alfalfa fields during the summer months will make much heavier gains than lambs running on the open range and depending on native grass. We could show lambs the fall of 1898 that were fit for any market and had tasted no grain since the last April. Sheep that run on alfalfa need little or no grain to fit them for market and this makes quite a saving.

The Arkansas valley is well adapted to sheep farming. Hay is cheap for winter feeding and the necessary grain can be raised here as cheaply as anywhere. For either breeding or fattening sheep I know of no place to equal the Arkansas Valley.

J. W. BROWN, Rocky Ford.

This is our first year of pasturing sheep on alfalfa. We pastured 500 ewes and their lambs on alfalfa for two months and then turned them on the range. We did not lose any by bloat. We did not move the sheep off the alfalfa when we irrigated. We have a large breed of sheep, the French Merinos, the ewes weighing from 140 to 200 pounds. We lamb early, feed for awhile in the corrals and this year we pastured on alfalfa for two months. This gives both the ewes and the lambs a good start and they do well on the range. We expect our lambs to weigh 90 pounds the first of October. Alfalfa is all right for sheep.

T. N. ORCUTT, Rocky Ford.

I have never pastured on alfalfa, but make it into hay

and feed the year around. I now have only pure bred Cotswold sheep at the home farm. I have two pastures, one of rye and one of blue grass; while one is growing they eat the other.

Alfalfa is not used for pasture for sheep in this section at all. Where it has been tried the losses were heavy. I understand that some feeders think they can afford to lose 5 to 10 per cent. This may do for toothless ewes, but my registered sheep are too valuable to take the risk. One of my neighbors put 1,500 sheep on alfalfa and I understand lost as high as sixteen in one day. Another tried it this spring, but the losses were so heavy he abandoned it. Near Las Animas they succeeded better, but here the alfalfa grows too rank.

A. FORDER, Rocky Ford.

I pastured one year 1200 ewes and their lambs on alfalfa for thirty days without any losses, then changed pastures and lost 75 ewes in about ten days, then changed to the range and will not try alfalfa pasture again. We did not irrigate the land while the sheep were there.

I have pastured old ewes and lambs on alfalfa after it stopped growing in the fall and did not lose any by bloat. We fed corn at the same time and the sheep did well.

J. P. STEVENSON, Rocky Ford.

I have tried for several years to run sheep on alfalfa; the result has been disastrous every time. Some four or five years ago I bought a bunch of New Mexican lambs, put them at first on very short alfalfa and kept them there for several days, then put them on better alfalfa. They commenced to bloat and before I took them out I lost 65 head. I had at the time a bunch of 300 native ewes. I put them on the same ground and gave them the same treatment and never lost one. The next spring these ewes were turned on the alfalfa as soon as it appeared green, but as soon as it got some growth they commenced to die and I had to remove them to native grass. I lost from one to four every day. Last fall I again bought 300 well bred Shropshire ewes. I put them on good alfalfa the first day I got them home and kept them there until night. I did not lose one. Next morning put them on again after dew was dry and kept them on all day; lost one. The third day I waited

until grass was dry and then put them on again. By noon I had lost nine head.

This spring I have kept the ewes up, fed them hay and let the lambs run through the fence and graze the alfalfa. They have done fairly well, but I believe if they and the ewes had other green grass and plenty of it as they do on alfalfa, that they would do better than on alfalfa. I have noticed one thing, that these lambs will leave the green alfalfa for dry hay and for a patch of wild grass. Still I have good lambs; some few January and February lambs weighed the middle of June 80 to 90 pounds.

All my sheep were turned on the range in June and I will bring them back the middle of August. Lambs dropped in April and fed as above ought to weigh 70 pounds the first of September.

My experience with pasturing sheep on alfalfa for six years has cost me several hundred dollars on account of bloat and that, too, with only a small bunch of 300 to 500 ewes.

I do not think I shall ever graze sheep on it again. The sooner the farmer who wants to graze his breeding stock on green feed gets something in place of alfalfa the better off he will be. People who have been buying old ewes at 75 cents to $1.00 per head and putting them on alfalfa have not lost much money if they lose ten per cent. of their ewes. But where the ewes are worth four to six dollars per head the case is quite different.

But although pasturing alfalfa has not been a success yet the sheep business, as a whole, has been profitable. This Arkansas Valley is a wonderful place for sheep. Our 1898 account stands as follows:

We had 35 lambs dropped in February and about 250 dropped in April and May. They went to the range June 10 and came back early in August. We commenced feeding bran and oats August 15 and got them on to full feed about the last of September, by which time they were eating one and three-fourths pounds of shelled corn per head per day. The latter part of October we sold 50 picked ram lambs at $10 per head. Fifteen of these came in February and the rest in April. Their average age was about seven months and they weighed 99 pounds per head. During November we sold 20 more ram lambs for $10 each. In December sold 40 ram lambs for $5 each. This left us 18 cull ram lambs. These 18 with 118 ewe lambs we took to Kansas City the last of December and after an extra hard trip they weighed 81½ pounds and sold for $5.40 per hun-

dred pounds or $4.40 per head. We had, therefore, total receipts of almost exactly $1500.00 from 246 lambs. We consider this a good showing.

JOSEPH CARL, La Junta.

We are pasturing 425 ewes and lambs on alfalfa the season of 1898. They have the run of twenty acres of alfalfa and up to June 8th, we have lost only one sheep by bloat. This is our first trial of pasturing sheep on alfalfa and so far we are well pleased with it and shall go into it on a larger scale next year.

S. H. POLLOCK, La Junta.

I undertook to pasture about 300 ewes and 225 lambs on alfalfa pasture, by feeding them well on corn and hay before turning them on the alfalfa and then leaving them there day and night. I left them three days and lost three ewes. I then gave it up and put them on the range.

GEO. W. PARKER, La Junta.

I have pastured sheep on alfalfa for three or four years and have lost on the average possibly two per cent by bloat. A good acre of alfalfa will support ten ewes and their lambs all summer. We turned the sheep off the land when we irrigated it. A cross bred Shropshire and Merino lamb pasttured on alfalfa ought to weigh 75 to 80 pounds, the first of October. From my experience, more especially with old ewes, I think well of lambing on alfalfa when the grass is short on the range and would especially recommend keeping the breeding ewes on the farm and feeding them nice green alfalfa hay before lambing instead of wintering them on the range.

R. A. McKIBBON, Lamar.

We run a few ewes, about fifty, on a small patch of eight acres of alfalfa. We have the lot divided and put the sheep in one while we irrigate the other. This is the second year we have tried it. We have lost two old ewes by bloat. We expect our spring lambs to weigh 75 pounds by the first of October. The season of 1898, we also lost a lamb by bloating.

G. W. MAY, Lamar.

During 1897 we pastured 1,000 ewes on 80 acres of alfalfa. This was our first year's experience and we lost nine per cent with bloat. We left the sheep on the land when we irrigated it. We began pasturing in April and by the middle of July the 80 acres proved not enough and we got 15 acres more. Even the 95 acres did not keep them and about the first of August we turned them onto the range. In 1898 we started with 160 acres, but by the middle of August the alfalfa was all gone and we had to turn them onto the range.

My belief is that not over 100 head of ewes should be pastured in one bunch on alfalfa and that at the rate of five ewes and their lambs to the acre. For larger bunches, if the alfalfa pasture was free of cost, it would be dear to use it on account of the great loss by bloat.

GEO. W. WILSON, Lamar.

We had several thousand ewes on alfalfa for forty days during the spring of 1898. Part of the time we kept them on day and night; part of the time they were corralled at night and turned out after the dew had dried off in the morning. Both plans were failures so far as preventing bloat was concerning and after losing about five per cent by bloat in the forty days, we gave it up and sent them to the range. I have satisfied myself that pasturing on alfalfa in the Arkansas valley is not practicable at least with large bunches much as I should like to have had it otherwise. At the same time I consider it the best district in any country for raising and feeding lambs.

JOHN McNAUGHT, Las Animas.

Have pastured sheep on alfalfa for six years. Fifty acres of good alfalfa will support about 500 ewes and their lambs the whole season. In different years we have lost from eight to ten per cent by bloat. We do not move the sheep off the alfalfa when we irrigate it. We undertake to give plenty of pasture at the start and then not move them. Our May lambs we expect to weigh about 60 pounds the first of October. We fatten our own lambs.

[NOTE -The present writer visited Mr. McNaught, July 14th, 1898 and saw his 500 ewes and their lambs on alfalfa. These were all old ewes, nearly toothless, which is

the reason for keeping them at home instead of sending them out on the range. The number lost to date by bloat was fifteen or three per cent. They had some forty acres of alfalfa to run on and were not keeping it at all close. Quite a share of those lost had been when some overflow water ran into one corner of the field. Mr. McNaught says that if the whole field had been irrigated, there would have been less danger of bloating than with merely a single spot. Mr. McNaught's doctrine in regard to pasturing sheep on alfalfa is never to let them get hungry. The best way is to have the fence coyote tight, but if this cannot be done, then corral them at night as he is doing this summer and let them out early in the morning.]

PURVIS BROS., Las Animas.

During the summers of 1897 and 1898 the grass was so good on the range that, as a general thing, it paid to run sheep on the range. Indeed, under these conditions of an abundance of fine grass, the lambs are almost as good as those pastured on alfalfa and the expense is less.

We had only about a hundred sheep on alfalfa during the summer of 1898. They did quite well. We had them, their lambs and ten horses on a twenty acre pasture and we could almost have cut it for hay. When the lambs were weaned the ewes were nearly fat enough for market.

The cause of the greatest loss from bloat is probably the necessity of corralling at night on account of coyotes. Where this plan is practiced the sheep should not be put into the corral until almost dark and turned out in the morning before daylight. The sheep generally bloat in the evening and this is due most likely to the practice of leaving them in the corral too late in the morning. Some actually put them in the corral at 4 o'clock in the afternoon, thinking to avoid the loss, as it is after this time that they generally bloat, and then leave them shut up until after the dew is off in the morning. This makes about sixteen hours in the corral and only eight hours on feed, consequently the sheep do not do well.

This year, 1898, was the fourth season for us of pasturing alfalfa with sheep. On the average we have lost about five per cent. with bloat. We have the field divided into two parts and pasture one while we irrigate the other. These were old ewes and were pastured all summer. We expect alfalfa fed lambs to weigh about 75 pounds the first of October.

[When on a visit to the Arkansas Valley in July the

present writer learned that Purvis Brothers have their fences coyote tight and do not have to bother about corralling the sheep at night. To still further lessen the danger from coyotes, they had taken to hunting them with greyhounds and had killed seventeen so far during the season.

To surround a whole farm with coyote tight fence would be rather expensive, but it would not cost much to fence five acres and drive the sheep in there at night, thus diminishing the danger from bloat.]

CHRISTIAN MARLMAN, Las Animas.

Pastured 470 ewes and their lambs on alfalfa during May and June 1898. They ran on about fifty acres of alfalfa. They were turned onto the range June 11 and remained there until the latter part of September. Lost in all about three per cent. by bloat. They ate all the first cutting, so that it cost us one-third of our hay crop. These lambs were dropped in March and weighed between 50 and 60 pounds when brought back from the range. We are well satisfied with the result and shall try it again next season.

JOHN E. DONLON, Las Animas.

In 1896 we pastured 1200 ewes with their lambs on 160 acres of alfalfa and lost about eight per cent. by bloat. That year we fed no grain. In 1897 we fed 1,000 ewes and their lambs on the same field. This second year we fed corn chop to the sheep and lost only 2 per cent. by bloat. Both these years we had aged ewes and kept them on the field all the time, even when we irrigated it. We would not risk young ewes on alfalfa. In 1898 we have had such excellent feed on the prairie that we kept our sheep on the range most of the season.

A. M. LAMBRIGHT, Las Animas.

During 1897 we pastured 750 ewes and their lambs on 100 acres of alfalfa and lost about three per cent by bloat. We kept them on the land the entire season, not changing when the land was irrigated.

In the spring of 1898 we started 1,000 ewes on 160 acres of alfalfa, but the feed on the range was so good that we turned them onto the range the latter part of May. If we

had kept them on the farm all the season, I think 130 acres would have been sufficient to feed them.

There have not been very many raising lambs here and what has been done has been done for only a couple of years. We have run simply old ewes on alfalfa so that the test so far as bloat is concerned is hardly a fair one for sheep raising in general. I am sure that old ewes do not bloat so much as young ones. Most of us have not invested in enough for fences to cut our pastures up properly. I think that if we had our pastures fenced so that there would be no danger from coyotes and would leave the sheep on the land all the time, there would be comparatively little danger from bloat if the owner would go around through them a couple of times a day and make them get up and eat a little. Some lost considerable here this year and have been scared out to the range. We have only lost three out of 1,000. Of this 1,000, not over one-third could be classed as old ewes. I have very little doubt but that there is a difference in size in an alfalfa fed lamb and one raised on the range of at least twenty-five pounds. The chances are that we could afford to raise nearer pure bred Shropshire or Hampshire Downs on ranches than we could afford to do on the range (for it is generally supposed here that none but Merinos or Mexican Improved with Merinos will herd on the range), and if this is done we can make a difference of at least fifty pounds.

SCOTT BROTHERS, Las Animas.

In 1898 our sheep are all on the range, the grass is so good.

A good stand of alfalfa will carry ten ewes and their lambs per acre the first year; the next year fewer and the next year still fewer.

Pasturing alfalfa by sheep is hard on the stand, as they bite out the crowns of the plant. We pastured sheep on alfalfa for one whole season and during the fall for three years. When pasturing the whole season we lost about five per cent. by bloat. We are very careful to leave them on the alfalfa all the time after they are once placed there, never changing them when the field is irrigated. Grade Shropshire lambs to which we had fed corn while on alfalfa weighed 75 pounds the first of October. Our grade Mexican lambs weighed 70 pounds. If we had not fed corn they would probably have weighed 5 to 10 pounds less. We fatten our own lambs.

JACOB WEIL, Las Animas.

During 1898 we did not pasture sheep on alfalfa, but have done so on two previous years. We were in the habit of taking them off the field when it was irrigated. Our lambs weighed about 65 pounds the first of October and we fattened them on the farm.

F. T. WIBBER, Fredonia.

We have pastured sheep on alfalfa for five years. The first year we lost ten per cent. Now we do not expect to lose any. We do not move the sheep when we irrigate. In 1898 we pastured 500 ewes and their lambs on 160 acres of alfalfa from early in the season until the first of July. They were then turned on the range and stayed there until fall. We expect lambs so treated to weigh 70 pounds the first of October. We fatten our own lambs.

A. F. KLINKERMAN, Fredonia.

We have pastured sheep on alfalfa part or all of three seasons. One season we lost as high as ten per cent. by bloat, but this was due largely to inexperience. During 1898 we let the ewes run on alfalfa during the six weeks of the lambing season and as soon as that was over we sent them to the range. We lost about one per cent. during the six weeks. We had about 500 ewes and their lambs on 50 acres of alfalfa. We have always left the sheep on the land when irrigating it. We expect May lambs to weigh 60 pounds the first of October if pastured on alfalfa. In 1898 we turned the ewes and lambs on the range the first of June. It probably took two-thirds of the first cutting of alfalfa to lamb the sheep on it, but we consider ourselves well paid in saving of lambs and the start it gave them and the old ewes before turning them on the range. We are satisfied that we saved at least fifteen per cent. more lambs than could be done on the range and also saved in the expenses of herders during lambing.

L. M. CAMPBELL, Fredonia.

We feed on alfalfa exclusively, no grain except to lambs born in the winter.

First make a fence with posts 10 feet apart, nine barbed

wires, stretched tight, 4½ feet high. This will turn a wolf or a dog and is the principal essential of running sheep on alfalfa pasture, since they must have free access to the feed day and night. Shade, salt and water are very essential. Have the sheep entirely free from hunger or thirst before turning them on the alfalfa.

In December, 1895, I bought off the range 100 ewes, each with a lamb by its side. They did well until the alfalfa started in the spring. Then we attempted to herd them on the alfalfa in the day time and corral them at night. Our loss by bloat in ten days was 12 ewes and 15 lambs. We put them on native grass for a few days until we could build such a fence as I have described. We enclosed 10 acres of alfalfa and 5 acres of timber. This was in April, 1896. I drove them over a wheat field to the alfalfa pasture to be sure they were full. I have not lost a sheep or lamb since then by bloat and I have no fear of ever losing one.

I have yet five head –four ewes and one buck—of the first 100 bought and they have never been out of that enclosure. The ewes are nine years old, the buck a few years older, and their teeth are as good as the average six-year-old on the range. We never take the buck away from the ewes.

Two of the four ewes had twins last November and the same ewes had twins again this year (1898) in May. The four November lambs weighed in the middle of June 70 pounds each, while the May lambs weighed at the same time twenty pounds each.

We wintered 85 ewes in that pasture during 1897-98 and raised in the spring of 1898 135 lambs, forty of which—the wether lambs—we sold in Kansas City in April, where they averaged 60 pounds and brought 6½ cents per pound, or $3.95 cents per head. The ewes sheared about 7½ pounds of wool apiece.

I think my pasture would support quite a number more sheep than we have on it, or about ten ewes and their lambs per acre. We irrigate with the sheep in the pasture and can see no bad effects. I do not advocate close pasturing. We have never fattened any lambs, selling them when they are three months old.

Sheep do their principal feeding at night. It would not be profitable to corral sheep at night when in alfalfa pasture, even if it were not for bloating. They will do much better when they can have access to feed both day and night.

Alfalfa pasture does not seem to be favorable to scab.

We bought our sheep from a herd that was infested and expected to dip, but so far have had no occasion.

I am a strong believer in pasturing as a method of handling our alfalfa. Conducted on the principles here described there is nothing in my judgment more profitable than handling sheep and I hope to see the day when every farm in Colorado will be supporting a flock of sheep.

The total income from these 87 ewes for the year from November 1897 to 1898 is as follows:

40 wether lambs sold in April @ $3.95..	$158.00
640 pounds wool from ewes @ 10c......	64.00
175 pounds wool from lambs @ 14c.....	24.50
35 ewe lambs saved for breeding @ $3.50.	122.50
52 lambs for market, 75 lbs. each, November 1, @ $3.00..................	156.00
	$525.00

Year's income per ewe $6.04.

IS PASTURING ALFALFA PROFITABLE.

It will be noticed from the foregoing letters that the pasturing of alfalfa by sheep is used for several purposes; sometimes for only a few weeks in the spring while the ewes are lambing; sometimes for very early lambs to fit them for the summer market; more commonly for old ewes that would not thrive on the range and by some as a regular way of keeping sheep.

It will also be noticed that there are certain things about which all are agreed. By inference we may judge that all agree, that for keeping wethers or ewes without lambs, alfalfa pasture cannot compete with the open range. This is undoubtedly true so that the only profitable use for alfalfa pasture is as feed for ewes with lambs.

It is also evident at the outset that alfalfa pasture is not cheap feed, not nearly so cheap as the range. If then it is to be used in competition with the range it must be because more growth is obtained on the lambs when on alfalfa than when roaming the range.

The question of raising early lambs on alfalfa and other feeds will be discussed in the latter part of this bulletin.

Here we are to consider the pasturing of lambs during the whole summer that are to be fattened on the same farm during the fall and winter for the eastern markets.

The practical question is, can this be done with as much profit as to range the lambs through the summer and then bring them to the farm for winter feeding. To the feeder of the Arkansas Valley at the present time, this is the simple proposition. But the time will come when the problem will present itself in another form. In the feeding districts of Northern Colorado that time has already come and the problem as it will appear in the future is this: There is or will be on the farm a certain amount of alfalfa. By which method can I realize the more profit, by making hay of it and feeding it to lambs in the winter or by using part of it as pasture for ewes and lambs during the summer and the rest to support the ewes during the winter?

The average of the statements from the various individuals seems to be about ten ewes and their lambs to one acre of good alfalfa pasture, running on the land from the middle of April until the first of October. This would require very good alfalfa and it is probable that eight ewes to the acre would be nearer average conditions. The ewes would feed on the stubble fields practically without cost during October and November, leaving four and a half months that they would have to be hay fed.

A full grown ewe will eat five pounds of hay per day or two and three-fourth tons of hay to run the eight ewes through the winter. If we estimate an acre to produce four tons of alfalfa, then it would require three-fourths of an acre to supply hay for the winter and one acre to pasture them during the summer.

What return could be expected as the income from this acre and three-fourths of alfalfa? For the last four years lambs have averaged being worth four cents a pound live weight on the farm the first of October. It is fair to presume that a person who was planning for pasturing alfalfa would have the lambs dropped in March and they ought then to weigh 70 pounds the first of October and be worth $2.80 each. The ewes would need to be fed grain for sixty days, one pound per day, costing in all forty cents for each ewe. The ewes should shear seven pounds of wool each, worth at least ten cents per pound.

The whole account would stand thus:

Income.

8 lambs @ $2.80	$22.40
56 pounds wool @ 10c	5.60
Total	$28.00

Expenses.

480 pounds grain	$ 3.20
Difference	$24.80

This difference of $24.80 represents the return from the land that will produce seven tons of alfalfa or about $3.50 per ton for cutting and feeding about half the alfalfa and letting the sheep harvest the other half.

Out of this return would need to be deducted the interest on the investment and any losses by bloat that may occur.

Whether or not any greater return for the alfalfa can be obtained in any other way, each farmer will need to answer for himself. It is believed that the items of income as given above are conservative estimates and that profits much larger than this would often be obtained.

IS PASTURING ALFALFA SAFE.

The answer must be given in the negative. But in view of the statements given by some of those who have had the most experience, the danger from bloat can be largely overcome and the loss reduced to at least not more than five per cent.

On the basis of the estimates already given, a five per cent loss by bloat would reduce the returns for the alfalfa fifteen cents per ton. If there is any profit in pasturing alfalfa, a five per cent. loss on the ewes would not reduce the profit to any serious extent.

There seem to be certain precautions that need to be observed in pasturing alfalfa to prevent bloat and they can be summarized as follows:

1. Have the sheep in small bunches, or if in a large bunch divide into several lots in separate fields.

2. Have a large enough field to supply them with an abundance of food with little effort.

3. Leave them in the field day and night and do not remove them when the field is irrigated.

4. Have water and salt before them all the time and if there are no trees in the field provide some sort of shelter against the sun.

5. Be sure they are filled up with some other food and not thirsty when first turned on the alfalfa.

6. Do not attempt to pasture on alfalfa anything but old ewes and their lambs.

It is probable that by following out the above directions the losses by bloat with old ewes can be reduced to less than five per cent.

II. RAISING EARLY LAMBS.

BY W. W. COOKE.

For many years there have been a few early lambs raised in Colorado. The large markets for early lambs—Chicago, New York and Boston—are so distant that Colorado can hardly hope to compete with the eastern states in supplying lambs in the spring to these cities. Kansas City and Omaha are near enough to be reached, but they are never able to handle very many lambs at one time and their total demand for early lambs is not large. The local market in Colorado is still more limited. It is evident, then, that not many people in Colorado can profitably engage in the raising of early lambs. But there is always a demand for some of these lambs and some one has to supply that demand. At the present time the attention of Colorado feeders is turned more particularly to the feeding of lambs raised in the south and west, because for them the market is almost unlimited and they can be handled by the thousands. The object of the present inquiry was to learn whether the small farmer can raise early lambs and realize as much for his labor and feed as his neighbor with the larger farm does with the older lambs.

During the summer of 1895 fifty ewes were purchased for the test. Half were grades of the Shropshire crossed onto the Merino, and the other half were Horned Dorset and Merino. They were a fine lot of ewes, all of them three years old, having dropped their second lamb the spring of 1895. They cost three dollars per head. Fifteen of the Shropshire ewes were served by registered Shropshire bucks, the other ten by registered Dorset bucks. Fifteen of the Dorset ewes were served by the Dorset bucks the other ten by Shropshire bucks. The lambs were dropped during January and February of 1896.

The fifteen Shropshire ewes that were served by Shropshire bucks dropped 14 lambs, of which 11 were buck lambs and 3 ewe lambs. The ten Shropshire ewes served by Dorset bucks dropped 13 lambs, 5 bucks and 8 ewes. The fifteen Dorset ewes served by Dorset bucks dropped 20 lambs, 16

bucks and 4 ewes. The ten Dorset ewes served by Shropshire bucks dropped 9 lambs, 5 bucks and 4 ewes.

To make the comparison a little easier to see, the above figures have been reduced to the basis of 100 ewes and give the following results:

	Lambs.	Sets of Twins.
100 Shropshire ewes served by Shropshire bucks dropped........	94	7
100 Shropshire ewes served by Dorset bucks dropped............	130	40
100 Dorset ewes served by Dorset bucks dropped	134	33
100 Dorset ewes served by Shropshire bucks dropped	90	0

Figured from the side of the ewe, 200 Shropshire ewes, half served by Shropshire bucks and half by Dorset bucks produced 224 lambs with 47 sets of twins. 200 Dorset ewes, with the same service produced 224 lambs with 33 sets of twins. Figuring from the side of the buck, 200 ewes, half Shropshire and half Dorset and all served by Shropshire bucks, produced 184 lambs with 7 sets of twins. 200 ewes, the same but served by Dorset bucks produced 264 lambs with 73 sets of twins.

It is evident from these last sets of comparisons that the prepotencey toward the production of twins lay with the bucks and not with the ewes. It is generally conceded that the Dorset is one of the most prolific sheep and the bucks ought to have had this quality more pronounced for they were pure bred while the ewes were grades.

So far everything seemed to favor the Dorsets as the more profitable sheep. But these lambs were dropped in the middle of winter and the twins did not seem to have the vigor to stand cold weather so well as those that had been born singly. Moreover the ewes seemed to be able to give an abundance of milk for one lamb but not enough for two.

The ewes were given grain, and a lamb creep was provided where cracked grain was kept all the time. The lambs learned to eat grain before they were a month old and after that, ate nearly as much as the ewes. Yet in spite of this the twin lambs did not do so well as the others and those that we lost were almost entirely from the twins.

We began selling March 10 and sent off the last May 21. The price was 15 cents per pound dressed weight.

The four sets of lambs of different parentage gave the following results:

Record for the Spring of 1896.

Dam	Sire	No. of Lambs.	Average Date of Birth.	Average Date of Sale.	Age in Days at Time of Sale.	Live Weight. Pounds.	Dressed Weight. Pounds.	Selling Price Per Head.
Shropshire	Shropshire	13	Feb. 1	April 20	79	47	22	$3 30
"	Dorset	10	" 3	" 25	82	48	22	3.30
Dorset	Dorset	15	" 9	" 16	67	47	22	3.30
"	Shropshire	9	Jan. 22	" 3	72	51	23	3.45
Total and Average		47	Feb. 1	April 16	74	48	22	$3.30

The reason that the dressed weights are so nearly equal, is that we sold from week to week, selecting the lambs as soon as they were large enough to dress over twenty pounds. We finally sold 47 lambs from the 50 ewes, of which 25 came from the twenty-five ewes that were served by Dorset bucks, while 22 were from the twenty-five ewes served by Shropshire bucks.

In the matter of rapidity of growth the ewe seemed to be the controlling factor, rather than the buck as might naturally have been expected. The lambs from Dorset ewes dressed 22 pounds by the time they were 69 days old, averaging 49 pounds live weight, while the lambs from Shropshire ewes required eleven days longer to reach the same weight.

Taking the whole experiment through, the Dorset ewes served by Dorset bucks gave the best results, giving us fifteen lambs from fifteen ewes that sold for $3.30 per head at 67 days old.

The average for all classes is January 30 for date of birth and April 16 for the date of sale when they were 77 days old, weighed 48 pounds alive, 22 pounds dressed and sold for $3.30 at the farm.

As fast as the lambs were sold the ewes were taken off from grain and when the last lambs were gone, the ewes were sheared and turned out to pasture on native grass until the next winter.

The same method of procedure was adopted in 1897, except that as the lambs were dropped a little earlier, they were allowed to grow a little larger before they were sold.

This season all the ewes were served by Shropshire bucks and though the lambs sold are one more than 1896, the difference in favor of the Dorsets is larger than in 1896.

There are 21 lambs credited to the Shropshires. One more lamb was dropped but so late in the season that it could not be sold with the others in the spring and was carried over until the next season. It is counted in the summary as worth $2.00, though of course we actually received more than that for it at the time of sale.

The record for the spring of 1897 is as follows.

Record for the Spring of 1897.

DAM.	No. of Lambs Sold	Average Date of Birth.	Average Date of Sale.	Age at Date of Sale, Days.	Live Weight, Lbs.	Dressed Weight, Lbs.	Selling Price.
Shropshire	21	Jan. 15	March 27	71	54	27	$4.05
Dorset	27	Jan. 12	April 2	80	56	26	3.90
Total and Average	48	Jan. 13	March 30	76	55	26.5	$3.97

Again for the third year the same experiment was repeated. The ewes were all served by Shropshire bucks, but were getting so old that several did not lamb the spring of 1898.

Instead of selling the lambs for slaughter they were all sold April 13 at $3.50 per head for breeding purposes. This was about the price they would have brought if they had been fed a little more grain and sold for meat.

The following is the record for the spring of 1898:

Record for the Spring of 1898.

DAM.	No. of Lambs Sold	Average Date of Birth.	Date of Sale.	Age at Date of Sale, Days.	Live Weight.	Selling Price
Shropshire	17	Jan. 1	April 13	102	61	$3.60
Dorset	23	Dec. 25	April 13	109	59	3.40
Total and Average	40	Dec. 28	April 13	106	60	$3.50

This closed the experiment. The total records for the three years will be considered first with reference to the two breeds, the Shropshire and the Horned Dorset. Then it will be treated as a whole with reference to the financial side of the question.

Shropshires.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price Per Head.	Total Selling Price.
1896	23	80	47	22	$3.30	$75.90
1897	21	71	54	27	4.05	87.05
1898	17	102	61		3.60	61.20
Total...........	61	84	54	26	$3.64	$224.15

Horned Dorsets.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price Per Head.	Total Selling Price.
1896	24	69	49	22	$3.30	$ 80.55
1897	27	80	56	26	3.90	105.30
1898	23	109	59	..	3.40	78.20
Total............	74	86	55	25	$3.57	$264.05

The financial results are in favor of the Horned Dorsets. The first year they grew the faster, but in both the other years the Shropshires made the most weight and sold for the most per head. But the Dorsets produced so many more lambs as to more than overbalance their slower growth. On the whole the Dorsets brought in $40 more than the

Shropshires or about one-sixth of the total income. This difference is due entirely to the larger number of lambs reared by the Dorsets. Their record is practically one hundred per cent. since 74 lambs were sold from 25 ewes in three years.

ARE EARLY LAMBS PROFITABLE.

It is a difficult matter to estimate the cost of running sheep in such small numbers as we had in this experiment. But we will give the income side and the winter expenses and each one can estimate for himself what the cost would be, in his own case, of carrying the ewes through the summer.

Year.	No. of Lambs Sold.	Age in Days at Date of Sale.	Live Weight.	Dressed Weight.	Selling Price per Head.	Total Selling Price.
1896	47	74	48	22	$3.30	$156.45
1897	48	76	55	26.5	3.97	192.35
1898	40	106	60	..	3.50	140.00
Total............	135	..	..	..	....	488.80
Average..........	45	85	54	25	$3.62	$162.93

The above figures show a yearly income from fifty ewes of $162.93 for the lambs. To this should be added the re-return for the wool. This has amounted to about 70 cents per year per head, or $35.00 for the 50 ewes. This gives a total yearly income of $197.93, or $3.96 per ewe. The ewes were sold at the end of the experiment for a little more than they cost, so there was no loss in that respect.

Here are some items that can be estimated in the expense of these ewes as follows:

The ewes were kept in the corrals and fed hay after about the first of November. As soon as the lamb was dropped grain was given to the ewe and continued until the lamb was sold. When on hay alone, the ewes ate about five

pounds of hay per head per day and decreased to about four pounds when a pound of grain was added. The lambs ate a pound of hay and a pound of grain after they were 30 days old until they were sold. This makes 85 pounds of grain for each ewe and 25 pounds of grain for each lamb, or 110 pounds of grain for the ewe and lamb, costing us on an average 64 cents.

Each ewe ate 715 pounds of hay and the lamb 25 pounds or 740 pounds of hay, which at $3.00 per ton comes to $1.11 or a total cost for winter feed of $1.75. Subtracting this from the income of $3.96 leaves $2.21 as the return for the summer feed of the ewes and the labor of caring for the sheep and lambs through the winter.

These returns compare very favorably with any that can be obtained from running sheep on the range. They represent a clear profit of at least forty per cent. on the investment. Indeed so profitable is the business that if one was sure of a market at the above prices there would be thousands and tens of thousands of early lambs raised each year in Colorado. But, as stated at the beginning of this article, the local market that pays these prices is quite limited and will buy only the very best of stock. There is money in the business for a few breeders near each of the larger cities, but if many went into the business they would break the market and themselves.

RAISING EARLY LAMBS IN THE ARKANSAS VALLEY.

The Arkansas Valley in Colorado is naturally tributary to Kansas City. There are more early lambs raised in the Arkansas Valley than in all the rest of the state together and most of these lambs are marketed in Kansas City, though a few are sent west to Pueblo and Colorado Springs.

The following quotations will give an idea of how the business is carried on and what returns are expected. It can be said as a preface to what follows that the early lamb business in the Arkansas Valley is founded almost entirely on the aged ewe. The old ewes that are too weak or have too poor teeth to stand another year on the range, are brought to the farm in the fall, bred to drop their lambs early, are fed heavily during the winter and spring so that by early summer they are in excellent condition for mutton and bring considerably more than could have been gotten for them fresh from the range the preceding fall. Thus there are two sources of income, the return from the lamb and the increased value of the ewe.

WM. AND H. G. GREENE, Olney.

We raised some early lambs in 1898 that were dropped from the latter part of January to the early part of March. Our experience is that owing to the extra care and feed necessary, these early lambs are not so profitable as the later lambs.

W. A. COLT, Manzanola.

We have been quite successful both in raising early lambs and feeding sheep on alfalfa. We breed the ewes to lamb in February and usually feed the ewe well and get her at least half fattened by lambing time. After lambing we feed the ewe all the grain she can eat and provide corn chop for the lambs. We usually have a "lamb creep" into an adjoining lot where the lamb can find corn chop and bran at any time.

As soon as the alfalfa starts we turn both ewe and lamb out during the day and provide grain and hay in the lots at night. The main point is not to compel the ewe to live entirely on the green alfalfa. There is some loss from bloat with the best of management, usually two to three per cent.

We often market the ewe and lamb in the same car, usually when the lamb is about three months old. Some, however, market the lamb and keep the ewe a few weeks and then send her in. All this class of sheep business is done with the old ewes. The ewe and lamb sometimes bring as low as five dollars, while some of our best farmers have received as high as seven dollars.

W. H. NEY, Fowler.

During the months of January and February, 1898, we lambed 350 Shropshire ewes. These were all young ewes and of course harder to handle during lambing than older ewes. We saved over 100 per cent. of large strong lambs. The work was easier than it would have been to lamb in summer time on open range or pasture; the cost no more; a larger per cent. of lambs saved; better lambs and no loss in the ewes. The result has been entirely satisfactory to us and I can see no reason why anyone, properly prepared for it, cannot do equally well.

We have comfortable sheep barns with ample room for all breeding stock. We feed liberally on alfalfa with mixed grain ration of wheat and oats in sufficient quantities to keep the ewes in good condition. The lambs get grain with their mothers and appreciate it.

We have raised California Merinos and Shropshires.

The California Merinos require more care and warmer quarters than the Shropshires. The Shropshires can stand any amount of dry cold and their lambs are soon up and strong. The Merino lambs must have close attention and warm quarters, but the same attention would be necessary during the spring months and then other farm work would be crowding and prevent the expenditure of the necessary time to make a successful lambing.

When spring comes winter lambs are ready to go to the range or pasture with their mothers and will hold their own anywhere.

E. M. SMITH, on the farm of A. M. LAMBRIGHT, Las Animas.

My early lambs in 1897 sold as follows: Lambs dropped in January sold in April at Kansas City for 7c per pound, live weight, and weighed 48½ pounds or $3.40 per head. None of these lambs had any green alfalfa, but the ewes were turned onto the alfalfa after the lambs were sold. These ewes were sold in Kansas City in June, weighing 81 pounds, at $3.85 or $3.02 per head.

My March lambs sold in Kansas City in June for $4.25 per hundred pounds and weighed 61 pounds or $2.60 per head. These lambs were dropped in the corral and were fed alfalfa hay, corn chop and bran until March 26, when they and the ewes were turned onto alfalfa pasture and remained there until they were sold in June. We had 600 ewes and 590 lambs on 95 acres of alfalfa and with the addition of one-fourth pound of corn chop per day for a ewe and her lamb, they kept in fine shape. We commenced selling in June and sold until fall. The ewes were sold as soon as fat, some ewes going with each bunch of lambs. The April lambs in August weighed 71 pounds. In 1898 the feed on the range was so good that we pastured but little on alfalfa.

JOHN McNAUGHT, Las Animas.

In 1898 I lambed 200 ewes in January and sold the lambs in Kansas City in March for 8c per pound. They weighed 53 pounds or $4.24 per head. Two weeks later I sold the ewes for $4.75 per hundred pounds and as they weighed 96 pounds each they brought $4.56 per head. Neither these ewes nor lambs had any green alfalfa.

In April and May I lambed 500 ewes on alfalfa pasture. They remained there until May 26 when they were turned on the range.